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SUBAK LAND INFORMATION SYSTEM BASED ON REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM IN DENPASAR CITY

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Abstract: *Subak in this paper is a unit of agricultural area, with names, have palemahan (paddy field resource), pawongan (human resources/farmers), and paddy field farming systems. Subak as local genious Bali, constructed since the 7th century, until now Subak system still exist in Denpasar. UNESCO, in 2011, rewarded Subak as a world cultural heritage. Ironically, not one district/city, and the Province of Bali has maps spatially Subak, they only have statistical data. The development era of technology and communications requires the ease and speed of getting data and the latest information with a high degree of spatial accuracy. The answer requires data base information based on information and communication technology (ICT). Worldview satellite imagery coverage of Denpasar in 2015, and ArcGIS 10.3 software used for mapping land and extensive rice fields of Subak (spatial data). Secondary data consists of land resources (LR), the primary data includes the name pekaseh delineation and area subak, human resources (HR) and agricultural activities were used as attribute data. Denpasar City has 41 Subak in 2015, Subak area on the analysis of satellite imagery (2008.6 ha) was smaller (520.4 ha) than the Central Statistics Agency (CSA, Denpasar 2529 ha), with r2 = 0.8967. Soil fertility moderate, land suitability agro-ecosystem very suitable (S1) for rice field and suitable (S2) for second crops and horticulture lowlands, required land cultivation and fertilization, suitable to crop needs. HR status of farmers as cultivators 72% and Landowners 28%. Subak paddy crop rotation pattern Denpasar City is paddy-paddy/palawija–palawija/paddy. The data base is composed of a map Subak Subak (spatial data), the data LR, HR and agricultural activities (attributes data).*

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1. INTRODUCTION

Planning, implementing, and evaluating of regional development in all fields require data and the most recent update, correct, and accurately, to suit the purpose and on target. The available data is generally a correlation table between multiple names with the component area of Land resources (LR), human resources (HR) and development activities are ongoing (Fang et al., 2015). Era of technology and communications would require the unit area based geospatial development, supplemented by data and basic information resource of the potential area.

Similarly, for the development of Agriculture requires a data base, in the form of spatial data (units of land development) and attribute data that consists of data of LR, farmers HR and farming activities are carried out in every area of development (Andersen et al., 1993). Results of research conducted by Lanya et al.(2014), produced maps of land zoning Subak (protected, buffer and can be converted), using high resolution satellite imagery (Ikonos, Quick bread, Worldview, Landsat 8 and software GIS (Arc GIS), high accuracy (98.5%), and can be obtained exact geographical location resulting from the analysis of satellite imagery (Goodchild, 1987). Further commented that the submission of information resource potential of agriculture based on remote sensing and GIS facilitate in establishing zoning Subak of rice field protection area of agricultural land in sustainable food.

Embryo of permanent agriculture in Bali was done by the Subak system; Bench terraces on sloping land on the volcanic landform, water resources derived from springs and orographic precipitation. Limited sources of water for agriculture of rice field, carried out through the equitable distribution of water, use

efficiently and planned water supply. Traditional water management systems are known to farming Subak systems. According to various sources, water control system built at the initiation of settled agriculture, is no longer moving, there is also mention the Subak was built in the 7th century. In the Regional Regulation (Perda Bali Province No.02/PD/DPRD/1972) Subak defined as traditional law community that have the characteristics of socio-agrarian-religious, a farmer association that manages the irrigation water in paddy fields. Ironically, prior to 2015 there has been no study on spatial limits Subak region. Subak Institutions in Bali receive incentives from the provincial and regency / municipality, with goal to preserve the natural and agrarian culture. Subak is perfect to implement the philosophy of Tri Hita Karana, there pawongan (Subak members/farmers), there palemahan (paddy field), and there Parahyangan (Pura). Subak in this paper is a unit of agricultural area, with names, have palemahan (paddy field resource), pawongan (human resources/farmers), and paddy field farming systems. For it does not discuss of Subak as water traditional setting organizations (Subak irrigation system).

Tri Hita Karana (human, natural/environmental and parahyangan) is the philosophy of the Balinese people, who always keep the balance of the relationship between society and nature, society and God. Symbolized by the parahyangan (Pura Subak) a place to pray, palemahan (paddy field), and members of Subak (Pawongan). Religious values and limited water resources are intelligently done by managing irrigation systems and irrigation agencies which are designated as socio-religious character. The main function is the management of irrigation water for the production of food crops, particularly rice and pulses (Windia, 2006). The existence of Subak as traditional institutions/organizations of indigenous Bali in agriculture is still exis. Subak as Bali local genious established by the United Nations Organization (UNESCO) as world cultural heritage. Subak system still exist in Denpasar, so that Denpasar entry into the World Cultural Heritage City.

Subak in Denpasar has an important role, both as a counterbalance the urban ecosystem, as well as primary agricultural resources in the success of development food security programs. Along with the information disclosure and communication, as well as the preservation of the Subak in Bali, GIS software can then be used as a medium to represent data and information on Subak into a computerized system.

Mapping rice area by means of satellite imagery and GIS have been conducted throughout Indonesia (Pertanian, 2012). The result was a map of paddy fields in Bali Province 985 ha is smaller than the CSA, Bali in the same year. While the results of the mapping paddy field by using technology, region, and in same year conducted by the National Land Agency, Data obtained by the difference paddy fields area with the data of the CSA only 113 ha. Similar research applications of remote sensing and GIS (Geographic Information System) for mapping rice fields in Bali has a 98.5% accuracy rate (I Lanya et al., 2014). The third that research used to calculate the area of paddy fields in Bali province associated with the balance of food. Map (spatial data) are not yet equipped with data and information on land resources (LR) and human resources (HR) as well as the agricultural activities of each unit map (polygon paddy fields management unit) as a data base (attributes) that are needed for agricultural development. For the land resource information system, GIS-based needs to be built to integrate spatial data and attribute data of agricultural resources (LR, HR), in order to facilitate the search for data and information easily and quickly (Rodo et al., 2017)

In this era of globalization, the development of agriculture requires a data base management unit of land, such as Subak in Bali region. Data base of spatial (map of Subak) need to be integrated with attribute data Subak resources through information and communication technology (ICT). Subak as agricultural land resources should be preserved and recorded by computer-based potential to provide added value to the data base of Subak. Data base of paddy fields of Subak is data and land information that controls plant growth. In outline, the data include: soil, water, farmers, and agricultural activity. These data are used to facilitate in implementation of smart people, smart environment, and smart agrarian economy. Subak region needs to be mapped spatially and supplemented by data paddy fields resources (LR, HR, as well as farming systems conducted by farmers) in the region by means of remote sensing and GIS, to get high accuracy and easily accessible data.

Land Resources Information System (LRIS) is one form of geographic information systems, where the data of agricultural land resources is a kind of sub-component data and geographic information. LRIS components and works the same way with com-component and how GIS is public unless the objects to be

examined are data and information on agricultural land resources (Sulaeman et al., 2015). Similarly, LRIS is as agricultural land resources-based computers, used for data provision, manage, process, storage and security, product manufacturing information relating to the LR and HR Subak paddy fields, as well as generate geographic referenced information.

2. DATA AND METHODS

2.1. Geographical area of Denpasar City

Denpasar city is at 08035'31 "- 08044'49" south latitude and between 115010'23 "- 115016'27" east longitude. Bordering Badung Regency in North and West, Gianyar and Badung Strait to the east, the total area is 127.78 km2. Denpasar city is composed of four sub-districts (North, East, South, and West), 43 Villages/urban villages with 404 banjar/hamlets (Figure 1).

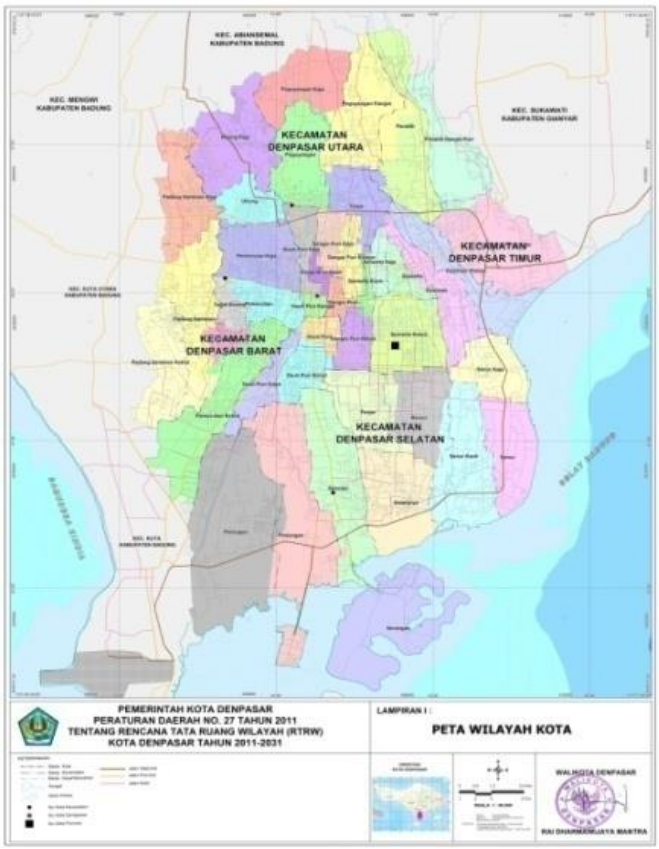

Figure 1. Map of Village Administrative Denpasar, (Bappeda, 2011)

Data from the BPS (2015), Denpasar City had 42 Subak, scattered in four districts, West Denpasar eight Subak, East Denpasar 14 Subak, South Denpasar 10 Subak, and North Denpasar 10 Subak.

2.2. Materials and research tool

The research material consists of: Satellite Imagery Worldview (WV) Denpasar 2015, maps support as secondary data (maps appearance of the earth and soil types), land suitability agro-ecosystem, soil fertility, statistical data CBS and data from the Dinas Pertanian Kota Denpasar (2014). Software Quantum GIS (QGIS) is used for: 1) mapping of boundary and rice area of Subak (spatial data) from the analysis of satellite imagery and field survey, 2) integrating the spatial data with the data of land resources (LR) consists of soil, water, vegetation, human resources (HR) and agricultural activities, and 3) presenting the spatial and attribute data in Subak land resources information system based on GIS.

2.3. Research methods

The research method used: (1) literature through secondary data collection, (2) the analysis of satellite imagery WV 2015, through a digitization polygon paddy field on the screen to get a subak tentative map, (3) The field survey to obtain information boundaries of Subak, HR primary data, and agricultural activities, (4)

create a land use map of Subak paddy field and non-agricultural land, (5) develop a data base of spatial and attribute data, (6) establish land information system of Subak. Point 2.4, 5 and 6 were done by using QGIS software. Beginning with the equation of the reference coordinate system used WGS 84 s/UTM Grid, created a polygon vector data (shp) with features add layers, Satellite Imagery Wordview 2015 Visual Interpretation and digitized on screen polygon layer of area Subak. This research used calculating fitur in QuantumGis to calculate the area of the subak area, join attribute and spatial data of Subak in QuantumGis, and make a layout map to add features composer, minimap menu was used to create edge of information maps.

3. RESULTS AND DISCUSSION

Delimitation and delineation of boundaries of Subak through a digitization screen on satellite imagery WV (tentative map), equipped with field measurements and observations, as well as interviews with the chairman/Kelian Subak a produce of Subak map (Figure 2). Figure 2 shows that the Denpasar city still has 41 Subak area of 2,008.6 ha, it is smaller (520.4 ha) than data from Denpasar CBS (2,529 ha), with the regression equation y = 0.7677 x +1.5887 with R2 = 0.8967. The value of R2 = 0.8967 means that there is a very real correlation between the area of Subak from the analysis of satellite imagery with data from CBS with 89.67% confidence level. Geographic locations spread across four districts. The smallest area was (1. 25 ha) Srogsogan Subak in West Denpasar and the largest was (152 ha) in Subak Temaga, East Denpasar District.

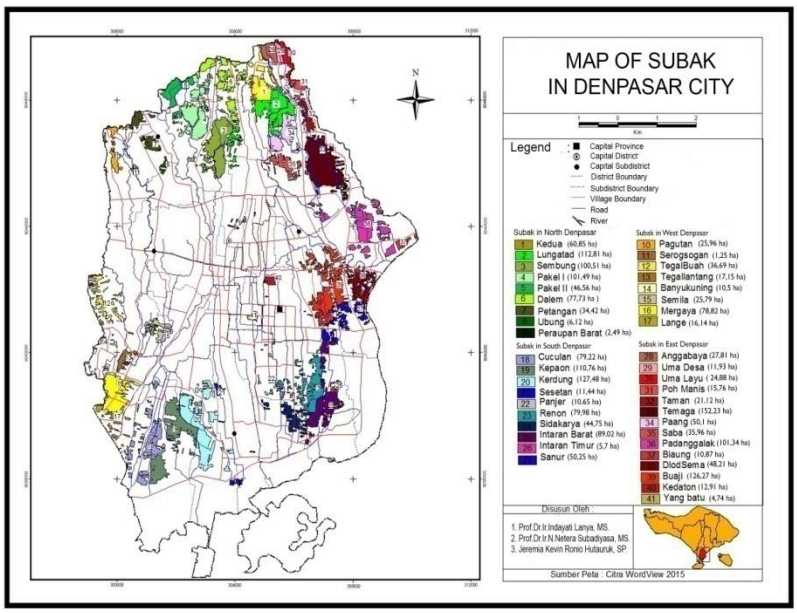

Figure 2. The Map of Subak in Denpasar City (analysis, 2015)

Differences of Subak paddy field from different sources are common, because it used different method. As the CSA in the study area (Denpasar) found a number of Subak mapping results by means of satellite imagery and GIS, which have been checking field, acquiring data 41 of Subak. Subak difference Peraupan East with an area of 15 ha is still listed in the statistical data. Subak existing condition in the field does not have paddy field since 1998 (the interview with Pekaseh). The word Subak paddy field mapping by using a remote sensing and GIS technology will obtain data and information more quickly, accurately, current/recent and its existence could be traced geographically/spatially, the data and information were more quickly and accurately obtained, when compared with the conventional data from this terrestrial survey.

Research done by Hutauruk et al. (2016) on Land resources information system (LRIS) of Subak paddy fields based remote sensing and GIS in Denpasar was able to provide information on potential LR, HR, agricultural activity in the 41 polygon of area Subak, quickly and easily identified and accessed. The same study in Badung produce 119 polygons of area Subak (Lanya & Subadiyasa, 2016). These results assist local

governments in planning and implementing the agricultural development in the city of Denpasar City and Badung Regency.

CSA data and the Department of Agriculture data were generally larger than the data results of mapping of by means of remote sensing and GIS technologies (Lanya et al., 2014). The subak paddy field area data as a baseline in agricultural development planning focuses on food security. The subak paddy field area affects the calculation of food availability in the region of Bali. Standard Information acreage of agricultural land which was greater than the real conditions will impact negatively on the self-sufficiency in rice. To get standard extensive data of high-quality paddy fields, the subak paddy field mapping required based remote sensing and GIS as spatial data and the need to put in regulations related to protect agricultural land and the national and regional food security.

The interpretation of satellite imagery and field observations were found in many buildings in the the Subak paddy field, and in the area of green open space (GOS), such as building houses, roads and housing conducted by the developer (Figure 3). The tendency of such violations the subak extends throughout the region, especially in South Denpasar bordering the tourism center of Kuta and Sanur. Paddy fields in the South Denpasar are very vulnerable to sense of urgency space for urban development and tourism support facilities. This is caused by the allocation of space in the Spatial Plan (SP) Denpasar City years 2011-2031, i.e. paddy field was allocated to non-agricultural land.

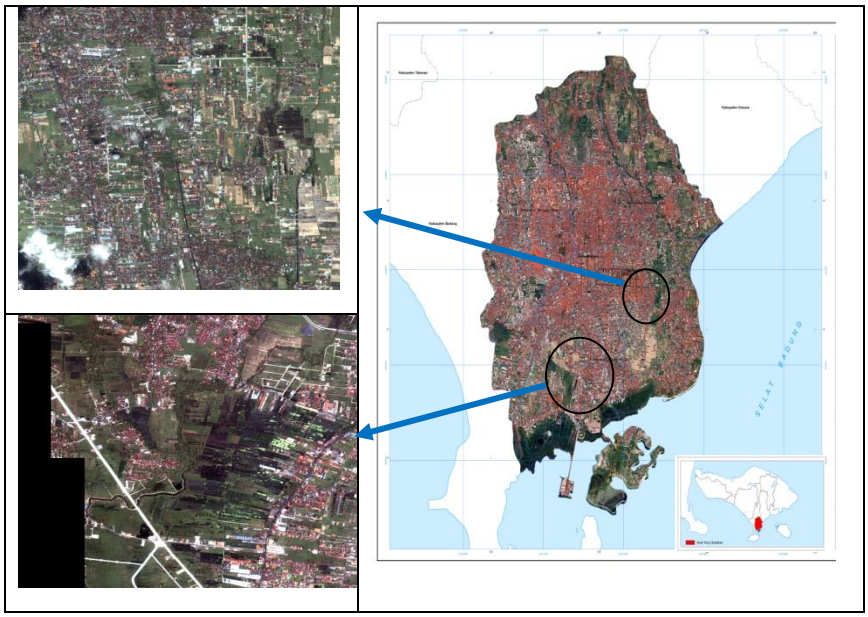

Figure 3. Satellite Image QuickBird Denpasar City 2013 (Bappeda , Kota Denpasar)

Information potential of NR, HR, and farming systems in the Subak paddy fields can be presented in table form (Table 1) and a map base on GIS (Figure 4). The subak Map (Figure 2) from the digitized satellite imagery as a spatial database integrated with Table 1 (examples Subak Kerdung) as a data attribute by using GIS technology to produce Figure 4.

Subak resource consists of land resource (subak area, munduk, plant type, water source, land suitability, soil type, soil drainage, soil texture, fer-abillity, fertilizer status), human resource (pekaseh name, farmer total, farmer status, member total, land owner) and agricultural activities (crop index, fertilizer types, fertilizer dos, production, irrigation type, crop type, seed source, pest and marketing).

The era of globalization, it will select information from Figure 4, because it is easily accessible, more communicative and based on information and communication technology (ICT). To find the desired information The subak potential, with the help of program GIS, fairly choose/click Subak spatial data locations are on the system, will perform a number of information NR, HR and agricultural activities that have been have developed as Subak selected attribute data.

Table 1. Data base of SDL , SDM and agricultural activities in Subak Kerdung in South Denpasar

Subak Name	Village	Subak Area From Pekaseh	Subak Area From CSA	Munduk	Plant Type	Water Source	Land Suitability	Soil Type
2	3	4	5	6	7	8	9	10
Kerdung	Pedungan	215	215	M.Siran, M.Kerdung, M.Buyuk, M.Nyalin, M.Timbul, M.Abasan, M.Babakan, M.Pitik	Paddy, Soy, Cucumber, Spinach, Kale	1. Tukad Badung, Bendung Mertagangga, irigasi Mertagangga 2. Tukad Badung, Bendung Batannyuh	Paddy, Soy, Corn, Chille, all vegetable except onion and spice, ginger, turmeric, Fruit as Melon, Sunflower,	Typic Tropaquepts, isohipertermik
Table 1 (Advanced)								
Soil Drinase	Soil Texture	Fert.Ability	Fertilizer Status	Pekaseh Name	Farmer Total	Farmer Status	Member Total	Land Owner
11	12	13	14	15	16	17	18	19
Hampered, rather HamperedTerhambat-agak terhambat	Smooth-Rather Smooth	CCgh-LLgh	Medium	I Wayan Tama	200	Owner = 20, Cultivator = 180	200	Personal = 215 ha

Table 1 (Advanced)

Crop Index	Fertilizer Type	Fertilizer Dos	Production	Irrigation Type	Crop Type	Seed Source	Pest	Marketing
20	21	22	23	24	25	26	27	28
245	Urea, NPK Phonska	Urea 200 kg/ ha, NPK Phonska 200 Kg/ ha	Paddyin dry season= 10 ton/ ha. paddy in wet season = 8,5 ton. soy 2 ton/ ha,	Sekun der, Tersier	Paddy-Paddy-Palawija	Paddy and Vegetable Seed From PT.PertaniBenih	wereng,Snail, bird, rat	Paddy sale to PT.Pertani, PT UPB Munggu, and Middleman

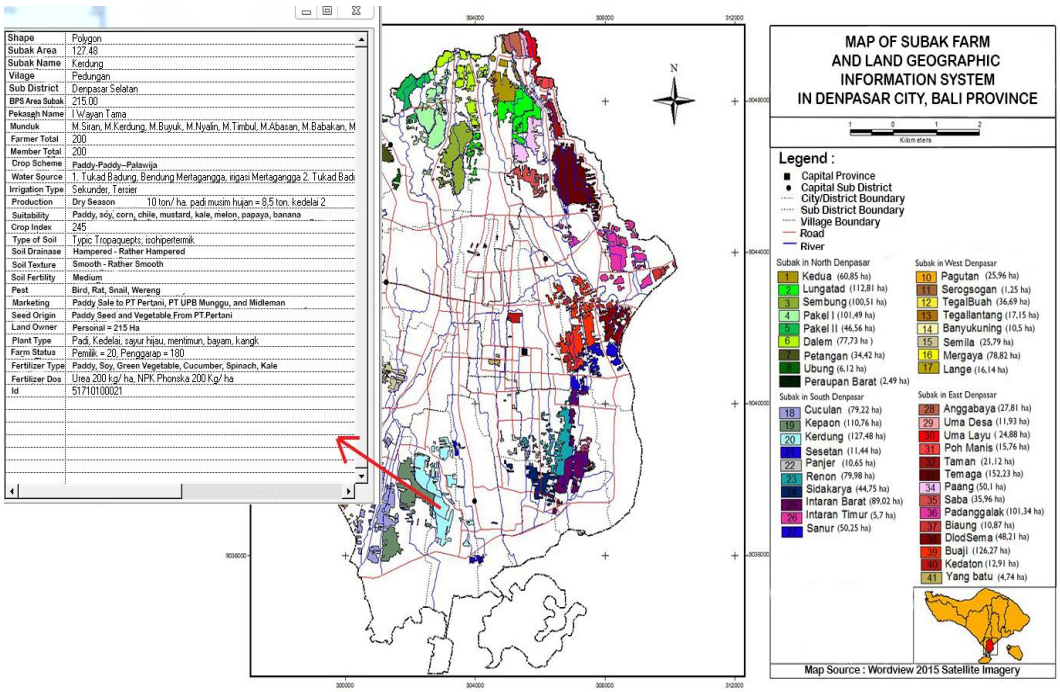

Figure 4. Display aplication of Subak paddy field Information System. Example Subak Kerdung

Generally NR Denpasar City is classified as good: moderate soil fertility, are suitable (S1) for paddy rice irrigated and suitable for horticultural crops and lowland. Needed input is the cultivation HR in general (72%) as peasants, landowners and only 28%. Crop rotation pattern in North Denpasar is paddy-grains, East Denpasar is paddy-paddy-grains, South Denpasar is paddy-paddy-crops, and West Denpasar is paddy--paddy crops/horticulture of land, irrigation, and fertilization in accordance with the needs of the plant to increase production of food crops.

The results provide information to the farming community that Denpasar already has paddy field information system Subak-based remote sensing and GIS technology. This system can aid in the development of technology-based, with the aim to provide solutions to various problems to enhance community welfare. As planning (e-planning), implementation (e-governance), monitoring and evaluation (e-Monev) agricultural development, as well as easy to give information on potential land resources, human resources, and agricultural activities in each Subak to Denpasar smart Cityin managing the natural, cultural, and environmental.

Resources Subak displayed using GIS was more easily and accurately, compared to the provision and performance statistics. GIS can integrate data attribute/of Subak resource database with spatial data/geographical position of the region of Subak, also makes it easy to calculate the area of raw paddy fields in the region of Subak. The data of land resources, human resources and agricultural activities in the region of Subak can be displayed and updated easily. During this time the data separate agricultural land resources and the only form of statistical data, so it is very difficult to obtain information on the resource potential of Subak easily, quickly and accurately. Research and Development of Land Resources (RDLR) develop Land Resources Information System, which is abbreviated SISULTAN in 2013, and develop in 2014 and it can be accessed via www.sisultan. Litbang.pertanian.go.id. Geospatial data presented in this system only (i) the rainy region, which presents the class of rainfall and its distribution. This data is sourced from climate resource map scale of 1: 1,000,000 published by the Research Institute for Agro-climate and Hydrology in 2000; and (i) spatial structure of agriculture (Sulaeman et al., 2015).

4. CONCLUSION

Delineation polygon of Subak paddy fields on the image of the Wordview 2015 and field surveys in Denpasar amounted to 41 Subak of Subak 42 CSA data. Remote sensing technology can provide spatial data more accurate than the CSA data.

Data base of Subak paddy fields cover land resources (subak area, munduk, plant type, water source, land suitability, soil type, soil drainase, soil texture, fert-abillity, fertilizer status), human resource (pekaseh name, farmer total, farmer status, member total, land owner) and agricultural activities (crop index, fertilizer types, fertilizer dos, production, irrigation type, crop type, seed source, pest and marketing), it can be integrated with a map of Subak, and can be called up easily and quickly to acquire a data base of agriculture in each name of Subak computer-based GIS software.

Land resources information system (LRIS) of Subak paddy fields can be used as a tool for local governments in formulating policies, take decisions or carry out activities related to agricultural development based on local wisdom.

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