



## STUDY OF LAND USE CHANGE ON TOURISM AREA USING HIGH SPATIAL RESOLUTION OF REMOTE SENSING IMAGERY

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### Introduction

Understanding determinants of land use in developing countries has become a priority for researchers and policy makers with a wide range of interests [1]. In the other hand, accurate and timely information about land cover in urban areas is crucial for urban land management decision-making, ecosystem monitoring and urban planning [2]. Remote sensing technology has great potential for acquisition of detailed and accurate land-use information for management and planning of urban regions for various purposes [3].

High spatial resolution satellite images offer a great potential for the extraction of land use and land cover related information for urban areas [4]. Although high-resolution imagery in the form of aerial photography has been available for many years, the launch of the IKONOS-2 by Space Imaging in September 1999 has signaled a new era in satellite remote sensing [5]. Utilization of high-resolution imagery data on tourism areas is important to understand causes and their effect

Basically, changes in land use are closely related to the availability of land and water. The availability of land and water resources determines

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the productivity of the resources and provides information about the potential of production. In general, land use is the result of continuous interaction, balance and dynamic conditions between people's activities in a certain area and the environmental constraints where they live in. Knowing the land-use distribution and its changes is not only useful for the sustainable management of natural resources, but it can also be used as information for a spatial planning in the future. Theoretically, land-use change is the process in which there is an increase in one type of land use followed by a decrease in another type of land use within different periods of time [6]. Land use change is driven by the interaction in space and time between biophysical and human dimensions [7].

Bali Province, one of the Indonesian tourism destinations, has major changes in land use annually, especially in the coastal area of South Bali [8,9]. In this area, coastal resources and tourism industry have been experiencing a tremendous coastal change due to the tourism development and associated commercial and residential growth.

There was also an alarming increase in land-use change in North Kuta District. North Kuta, located in South Bali area, was originally a rice-field area has now become a tourist area. Accommodations especially villas have developed rapidly in this area. Land-use change from paddy fields into settlements happens the most in the South and East namely the areas that are parts of Kerobokan Kelod Village Kerobokan Kaja Village, Dalung Village and Canggu Village [10]. The Land-Use Map shows that there were more conversions of paddy fields into settlements during the period of 1992 to 2003 in the northern region, such as Kerobokan Kaja and Dalung. However, during the next period (2003 to 2008) there was a change in the trend in which land-use change from paddy fields into settlements was more concentrated in the

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southern part, such as Kerobokan Kelod and Canggu Village.

This condition was driven by the development of the tourism sector which was in fact concentrated in the South and East, as a result of the impact of regional growth in Kuta District which is the generator and the center of tourism growth in South Badung. Various tourist accommodation facilities such as villas and restaurants as well as various supporting facilities seemed to flourish in the South and East parts. Based on the district land-use map of 1992, 2003 and 2008 [10], the southern areas, which mainly comprised of paddy fields in 1992 were gradually converted into settlement areas in 2003, and the change happened more rapidly close to the year of 2008. The development of settlements generally followed the pattern of the road network that existed in that era, especially the roads with the status of the provincial and state roads. This fact is strengthened by the data of land-use change in the level of Kerobokan Kelod Village where the total land-use change from paddy fields into settlements was 21.25 hectares in a span of 3 years (7.8 hectares/year).

The purpose of this research is to classify and calculate land-use change from 2006 to 2009 using high spatial resolution remote sensing data in two tourist areas namely Canggu Village and Kerobokan Kelod Village. Both villages are located in North Kuta District and have a quite rapid development in tourism.

## **Data and Methods**

### *Research Location*

The research was conducted in Kerobokan Kelod and Canggu Village, part of North Kuta District in South Bali areas. Fig. 1 indicated the research location. Spatial analysis of remote sensing data was used to analyze the changes in land use in Kerobokan Kelod Sub-district and

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Canggu Village of North Kuta District. Identification of changes in land use in a region is a process of identifying differences in the presence of an object or phenomenon that is observed at different times. Identification of changes in land use requires a temporal spatial data

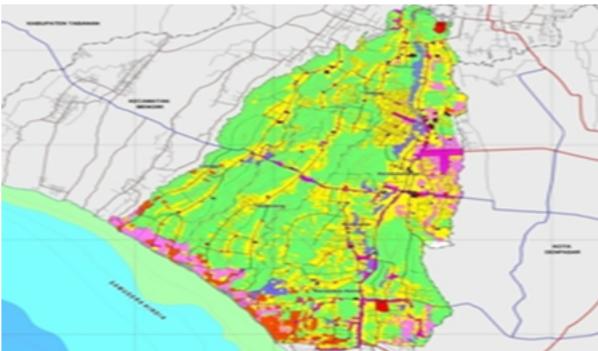


Fig. 1 Research Location. Black areas indicated the Canggu Village and Kerobokan Kelod Village.

such as remote sensing data [9]. Remote sensing data for land-use-change analysis have been used by several researchers to study various subjects [e.g. 8,11,12,13, 14, 15, 16]. However, there are still very few researchers who use remote sensing to study the subject of tourism.

The materials and devices used in this study were: QuickBird satellite images

recorded on May 16, 2006, which were used to map the types of land use in 2006; QuickBird satellite images recorded on October 15, 2009, which were used in determining the type of land use in 2009; a digital map of the earth of Indonesia in the scale of 1:25,000 obtained from the Geospatial Information Agency (BIG, previously named Bakosurtanal) which was used as a base map in the satellite image interpretation, Global Positioning System (GPS) to determine the coordinates of the research sites, as well as a computer for data analysis of remote sensed



images.

Remote sensing satellite image data, QuickBird year 2006 and 2009 were visually interpreted using the approach of interpretation [17]. On-screen digitizing method through computer screens was applied for the visual interpretation process. On-screen digitizing method has been applied for land-use mapping from satellite images carried out independently [9,18,19,20] as well as by organizations in the United States [21]. The results of the analysis with the on-screen interpretation method were evaluated by field observations (to find out the ground truth) to check the correctness level of analysis results that include observations of the types of land use in the areas under the study and their surrounding [22]. The geographical position of the observed location was determined by measuring the coordinates of the observed location using GPS. The data providing information from field observations in the location where the coordinate samples were taken were processed and matched with the data analysis of QuickBird images as the primary resources in refining the analysis and classification of land use.

The primary analysis in this study is the analysis of changes in land use for all locations in Kerobokan Kelod Sub-district and Canggu Village of North Kuta District. The total land-use change between the year of 2006 and 2009 was obtained by comparing the areas of types of land in both spatial data. Meanwhile, the total area of land-use types in the two villages/sub districts was obtained by cutting the spatial data of land use in each year of observation with the administrative boundaries of Kerobokan Kelod Sub-district and Canggu Village. ArcGIS 10 software was used in the process of interpretation of land use and spatial analysis of the land use data with the help of Image Analysis extensions while the Microsoft Office Excel 2007 software was used to analyze attribute

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data.

Based on the analysis results of land use change, detailed verification was performed using Google Earth and field observations. This was done to find out the facts on the ground about the changes and the trends in the use of resources, especially the exploited land and water. By knowing the changes in land use, the type and characteristics of the changes as well as the exploited natural resources, the impacts that will arise can be predicted and the solution to deal with such impacts on natural resources can be anticipated.

## **Results and Discussion**

The trend of changes in land-use in two sub districts representing two different characters of area, namely Kerobokan Kelod Sub-district that has become an urban area and Canggu Sub-district that is still relatively agrarian, showed interesting dynamics over a span of three years (2006-2009). Kerobokan Kelod as a sub district that is located closer to the epicenter of the tourism development of Kuta (Seminyak and Legian) was noticeably affected more strongly and thus experienced rapid dynamics of land-use change. On the other side, Canggu Sub-district experienced slower dynamics which were apparent in the rice fields that still survived, at least during the period of three years (2006-2009).

The dynamic change of land-use in Kerobokan Kelod is indicated for example by the process of land conversion from a rice field area into a non-rice field one over about 21 hectares and also by the shrinking amount of vacant land by 12.6 hectares. Therefore, in total there are about 33 hectares of land that have gone through a change of function into an area of buildings and settlements in Kerobokan Kelod for 3 years (an average of 11 hectares/year). Similarly, the ratio of building



area and green area in Kerobokan Kelod in 2009 already showed an alarming rate, which reached 68.9%. It means the area of constructed land has grown by more than half of the total green/open area (Table 1).

From the map in Fig. 2 it is noticeable that the areas experiencing the highest functional changes in Kerobokan Kelod are located on the eastern and southern parts, and are generally positioned close to highways. This phenomenon is evidently a result of the great influence of the development of tourism in Seminyak Sub-district which lies precisely on the south of Kerobokan Kelod. The area of Kerobokan Kelod has turned into some kind of a receiver of the massive development that has already reached its peak in the areas of Seminyak and Legian. The spread of developments that were taking place and recorded until the year 2009 will continue to happen and be directed to the West, which is Canggu Sub-district. This is the area growth phenomenon of 'effects of the South' which also occurs in other regions or other villages in South Bali.

The settlements in the sub-district of Canggu form a linear pattern which follows the paths of the roads and the river. The settlements that have been formed give an impression that they block or cover the rice fields that are located behind them. The settlements are spread evenly in all parts of the area, whether in the upstream, midstream, or downstream areas. This is in contrast with the pattern of settlement in Kerobokan Kelod which forms a pattern of checkers that are spread out, scattered, and disorganized. The linear pattern formed in Canggu signifies that the village is still agrarian in character. Meanwhile, the dynamics of land-use change in Canggu occur relatively slower. The rate of the reduction of rice-field land is recorded to be only 0.94 hectares, whereas of dry land 0.09 hectares, and of mixed farms 1.34 hectares. Therefore in total there are approximately 2.37 hectares of rice field

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land, dry field, and farm land whose functions are converted (an average 0.79 hectares/year). Similarly, the increase in the area of land that serves as constructed land is relatively small, that is 3.75 hectares (Table 2). However, if these data are linked in a rural context it will become clear that what has happened in Canggu has shown a considerably dynamic progress of land-use change.

Table 1. Change of Land Use in Kerobokan Kelod Village in 2006 and 2009

Land Use	Area of land use (hectare)		
	2006	2009	Change
Building	158.18	178.89	20.71
Road	16.34	17.08	0.74
Mixed Farm	41.26	43.18	1.92
Swimming Pool	1.22	1.67	0.46
Dry Field	2.51	2.81	0.31
Vacant Land	60.72	48.07	-12.66
Sand	10.73	10.73	0.00
Settlement	252.29	262.02	9.73
Rice Field	185.81	164.56	-21.25
River	0	0	0

An interesting phenomenon occurring in Canggu is the appearance of vacant lands (of approximately 36 hectares) and a large area of shrubs in the border area of the southern beach in Canggu Sub-district (Fig. 3).

All this while those vacant lands and the bush lands have been functioning in ecological terms to withstand the onslaught of the abrasion caused by the Southern Beach waves. The vacant lands are most likely lands that are already owned by foreign investors that on a momentum one day will be used for tourist accommodations. At this moment a number of villas have been established along the southern beach of Canggu.

There is a possibility of this phenomenon to be followed by the emergence of other tourist accommodation facilities in the future, along with the increasingly welcoming attitude of the people of Canggu towards the development of tourism.

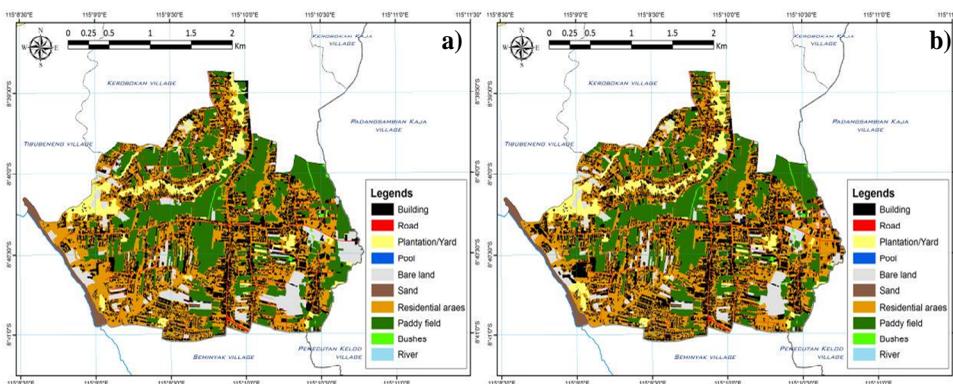


Fig. 2 Land use maps of Kerobokan Kelod Village. (a) 16 May 2006, and (b) 15 October 2009

Based on a further observation through Google Earth and field observations, several propositions can be suggested as follows. The change of land-use in Kerobokan Kelod Sub-district, particularly judged by the development of the buildings and vacant lands occurred far more rapidly than in the village of Canggu. Most of the development with regard to buildings is related to accommodations or villa buildings which are generally built on paddy field areas. This suggests that the declining area of rice fields in Kerobokan Kelod Sub-district (11 hectare/year) is much faster than in the village of Canggu (0.9 hectare/year), and it can be predicted that the development of villa buildings in the village of Canggu will occur more rapidly in line with the development in Kerobokan Kelod Sub-district, so that these two areas will face the problems of shrinking land (rice-field lands) which is the appeal of the area to tourists in addition to being the source of staple

food for the local people.

The type of land-use change occurring in both of the sub-districts/villages is dominated by the change of land-use from rice-fields into buildings. The type of buildings that are flourishing is in general accommodations/villa buildings. The construction of villas in both of these areas are getting interesting to discuss for a reason that each room or villa unit is generally completed with a swimming pool. This indicates that in the two areas people will face the problems of water shortage.

This is carried out to identify the actual facts on the change occurring and the trend of the natural resources, particularly land and water, that are being used. By recognizing the change of land-use, the types and characteristics of change that take place as well as the natural resources that are used, the consequential effects can be predicted and an anticipative solution can be determined to protect such natural resources.

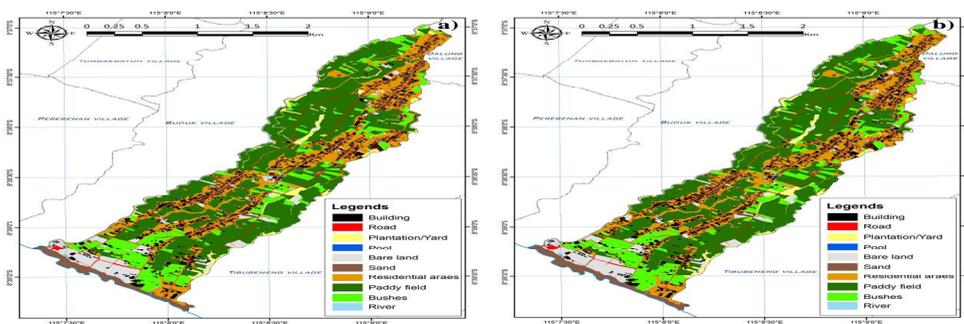


Fig. 3 Land use maps of Canggu Village. (a) 16 May 2006, and (b) 15 October 2009



Table 2. Change of Land Use in Canggu Village in 2006 and 2009

Land Use	Area of land use (hectare)		
	2006	2009	Change
Building	56.78	60.52	3.75
Road	18.60	18.62	0.02
Mixed Farm	24.10	22.76	-1.34
Swimming Pool	1.07	1.24	0.17
Dry Field	72.20	72.12	-0.09
Vacant Land	35.73	36.08	0.35
Sand	15.14	15.14	0.00
Settlement	115.62	113.71	-1.91
Rice Field	240.48	239.54	-0.94
River	0.19	0.19	0.00

## Conclusions

The analysis of satellite image data with the geographical information system to obtain the data on land-use and its changes indicate that there was a change in the type of land use in the North Kuta District, especially in Kerobokan Kelod Sub-district and Canggu Village between 2006 and 2009. Kerobokan Kelod Sub-district is the area that undergoes the largest change of land-use, either with an increase or reduction in types of land use. The increasing types of land use that are present in the region are mainly buildings and settlements. Building areas increased by 20.71 hectares during the period of 3 years, while settlements only increased by 9.73 hectares in the same period. Reduction of land-use types that occurred in this region was the reducing area of paddy fields in the total of 21.25 hectares during the period of 3 years followed by the reducing area of vacant land by 12.66 hectares in the same period.

Furthermore, Canggu Village had the increasing area of land use in the forms of buildings by 3.75 hectares and vacant land by 0.35 hectares only. Meanwhile, the reduction of land use was in the form of 0.94



hectares of paddy fields and settlements by 1.91 hectares. If changes in land use that took place in Canggu Village and Kerobokan Kelod Sub-district are compared, changes in Canggu Village are smaller than that of Kerobokan Kelod Sub-district. This happened due to the locations of the two regions, where Kerobokan Kelod Sub-district is closer to Kuta District which is the center of tourism growth in Badung and Bali.

Building area developments that occurred in Kerobokan Kelod Sub-district and Canggu Village are generally dominated by tourism facilities in the forms of accommodations or villas. The development and existence of accommodations in this area should receive more attention because in addition to converting fairly extensive areas of paddy fields they will also utilize quite a significant amount of water resources. Thus, the development of tourism in the two regions does not only reduce the paddy field areas but also leads to lower amount of water supply.

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