

MONITORING OF LAND USE CHANGES USING AERIAL PHOTOGRAPH AND IKONOS IMAGE IN BEDUGUL, BALI

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Abstract

There was change of expanding land use in Bedugul, It is necessary to monitor the change of highland of Bali, catchments area of Bcratan, Buyan and Tamblingan lakes. In order to control land use change and to anticipate degradation of hydrology function of this area. This study is to monitor the land use change by remote sensing and GIS technique. To evaluate land use and land cover, aerial photograph imagery and Ikonos imagery were used.

Over 22 years of observation (1981 - 2003), there \vas land use changes in the calchments area of Bcratan, Buyan and Tamblingan lakes at Bedugul area. The area of settlement increased by 62.6 ha, dry land vegetable crops increased by 7.5 ha, and shrub increased by 26.2 ha. On the other hand, areas of coffee crops and forest decreased by 116.5 ha and 32.5 ha, respectively. The surface area of Buyan Lake was also decreased, due to sedimentation caused by erosion in the vegetables dry land crops. Planning the land use study on erosion and soil-water conservation in this area are necessary, in order to control land use change, erosion, and sedimentation in the lakes

Keywords : land use, monitoring, aerial photograph, Ikonos image.

1. Introduction

The increase in the number of population in Bali Province in the last 22 years is very rapid. In 1981 the total population was 2,369,724 people. Twenty two years later in 2003 it increased to 3.139.022 people (Regional Development Planning Agency of Bali Province, 2004). This increase of population will need more land. Land resources are limited in number. Therefore, it is assumed there has been a change in land use, towards marginal land use (land in terms of conservation is not suitable for food plants or agriculture in general), especially in Bedugul one of the highlands in Bali.

According to the Bali Government Regulation Number 4, 1996 concerning with Space Planning of Bali, the

catchments area of Bedugul is a protected area. Geologically, the three lakes in this area is a unity of caldcra Ancient Beratan Volcano. However, recent development shows that the function has undergone some changes.

There was a change in the land use in the northern and southern side of Beratan Lake. The southern and eastern slope of Buyan Lake became the area of annual crops. This is accompanied by the plan of land use for the activity of agriculture and horticulture, the development for housing and tourism facilities such as hotels, restaurants and the likes. The change of land use in this area is more triggered if the geothermal project is to be planted in this area.

Land cover is related to the object that

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can cover the surface of the earth, while land use is related to the man activity (Lillesand and Kiefer, 1994). Vink (1975) defines land use as human interference to the land resources either fixed or a cycle that aims to fulfill his needs in terms of object or soul.

Multiple system of remote sensing have been used in the mapping of land cover and land use. The use of aerial photograph for mapping in this field has been applied since 1940s (Lillesand dan Kiefer, 1994). At present satellite data is much used for mapping and land use, using Landsat MSS image, Landsat TM, SPOT MSS and ikonos, and likes. Lindgrcn (1985) stated that, especially for vast area, remote sensing technique is only an effective way to monitor and obtain data of land cover and land use.

Remote sensing is very useful for monitoring of the change of land use because it can monitor continuously. In term of satellite image, the repeated recording is made frequent, that is once in 16 days for Landsat image and once in 5 to 21 days for SPOT image (Sutanlo. 1987). The revisit time of Ikonos satellite is approximately 3 days at 1 metre resolution. If we can use satellite data with short repeated frequency, it is available to monitor the quick change of land use such as development of a city, the decreasing area of forest, area of agricultural plants, and so on.

The change of land use that is uncontrolled and without soil and water conservation practices, land can cause erosion which in turn cause reduce soil productivity. On the other hand, erosion can also cause sedimentation accumulation and shallowness of lake, dam, river, channel, and other water bodies (Arsyad, 1989). Then erosion and sedimentation can act as pollutants that can reduce the quality and quantity of soil and water resources.

The change of land use in Bedugul will influence to the function of Beratan,

Buyan, and Tamblingan Lake, especially the preservation of soil and water resources. Based on this, it is necessary to study method for monitoring of land use associated with system that can guarantee the preservation of soil and water resources

II. Methods

Monitoring of the change of land use is made by remote sensing technique. Land cover and land use are monitored for period of 22 years (1981 - 2003) in Bedugul. In order to obtain the condition of land cover and land use in 1981, black and white panchromatic aerial photograph image with the scale 1:50,000 was taken on 16, August, 1981. Colored panchromatic Ikonos image of May 3, 2003 with resolution of 1 meter was taken and ground survey was made to obtain the condition of the land use. Ikonos data recorded 4 channels of multi spectral data at 4 meter special resolution and one panchromatic channel with 1 meter special resolution.

Interpretation of image is made visually. The interpretation method practically consists of detection, identification, delineation, and notation. Detection and identification are based on the difference of color and gradation. The interpretation elements are used: tone, color, pattern, shape, size, high, shadow, texture, site and association. The interpretation of aerial photograph is made by means of stereoscopic principles (three dimensional views) using mirror stereoscope. Delineation is made by grouping objects that a similarity in the key interpretation and limit different traits. Giving name and classification were done based on the classification were of land cover and land use devised by Malingrcu, Christian! (1982), and Wiradisatra(1985).

For the interpretation of remote sensing image, the map of land cover and land use produced in 1981 and 2003 were applied. Calculation of the area of land use is made by means of GIS technique (Arcview 3.3).

With results of the mapping, the analysis of the change of land cover and land use is also made. Flow diagram of the mapping of land cover and land use through method of image interpretation is presented in Figure I

III. Results and Discussion

The areas of each land use type in 1981 and 2003 are presented in Table I. Spread of land use as the result of the interpretation of aerial photograph in 1981 is presented in Figure 2. Figure 3 presents the spread of land use as the result of interpretation of Ikonos image in 2003.

It was found that the areas surrounding the lakes are difference between the secondary data that published by local government (Regional Development Planning Agency of Bali Province, 2004) and by the result of Ikonos interpretation. The previous published data stated that the widest lake was Beratan Lake with the area of 385 ha. but from the interpretation of Ikonos and GIS technique showed that the widest lake was Buyan Lake with the area of 478 ha. Over 22 years of observation (1981 ~ 2003) there had been a change of land use in Bcdugul. Land use that has undergone some changes is settlement, dryland, mixed crops plantation and bush and the lessening of plantation area for coffee and forest.

The area of settlement in Bcdugul was increased by 62.6 ha. The expansion of settlement area is caused by the development of hotels or lodgings, and new villas. The newly built hotels among others are, Enjung Beji Hotel and Restaurant and PLN housing located in the north of Pura Ulun Danu Beratan, and Danau Buyan Hotel located in the east of Buyan Lake are among the new buildings. Some newly built villas in the western side of Bedugul road, Bukit Bcrbunga Villa in the north of Beratan Lake, villa in the south of Buyan Lake, and some new house in sub village of Bukitcatu. The expansion of

settlement will be more intensified, if the development of Hotel Bali Bedugul Lake Resort (BBLR) in the western side of Lake Beratan and the geothermal project will come to completion.

Dryland where are planted with agricultural food and horticulture increased 7.5 ha. The expanded area is caused by the change of coffee crops in Pancasari Village into dryland, planted with vegetables. This change is very noticeable in Pancasari Village located in the south of Buyan Lake. The coffee plantation in this area is changed into dryland vegetables crops. This change is much clear with the development of strawberry plantation by Mustika Nusantara Abadi, Ltd in 1991.

The conversion of area of coffee crops into vegetable dryland also occurred in Candikuning, especially in the sub-village of Kembang Merta and Candikuning I. The residues of coffee plants still exist in Pancasari Village, the southern part of Buyan Lake. Old coffee trees are still remained in the dryland of which slope is very steep. But coffee trees look old and unproductive. Available coffee plantation now is 14.3 ha since the original area of 130.8 ha in 1981. Thus, there was a decreased of 116.5 ha.

The expansion of dryland in the south of Buyan Lake is not accompanied with the implementation of adequate soil and water conservation practices that cause erosion or sedimentation accumulation and shallowness in Buyan Lake. The shallow area is partly used by farmers to plant vegetables. In the study site, there is a decreased in forest area by 32.5 ha. Part of the forest area changes into shrub. This is noticeable in the eastern foot of Pohen Mountain. The decreased of forest into shrub was caused by bush fire happened in this area in 1994. This increased the number of shrub by 26.2 ha. The decreased in the area of forest is caused by the development of the exploration of geothermal project for electricity by Bali

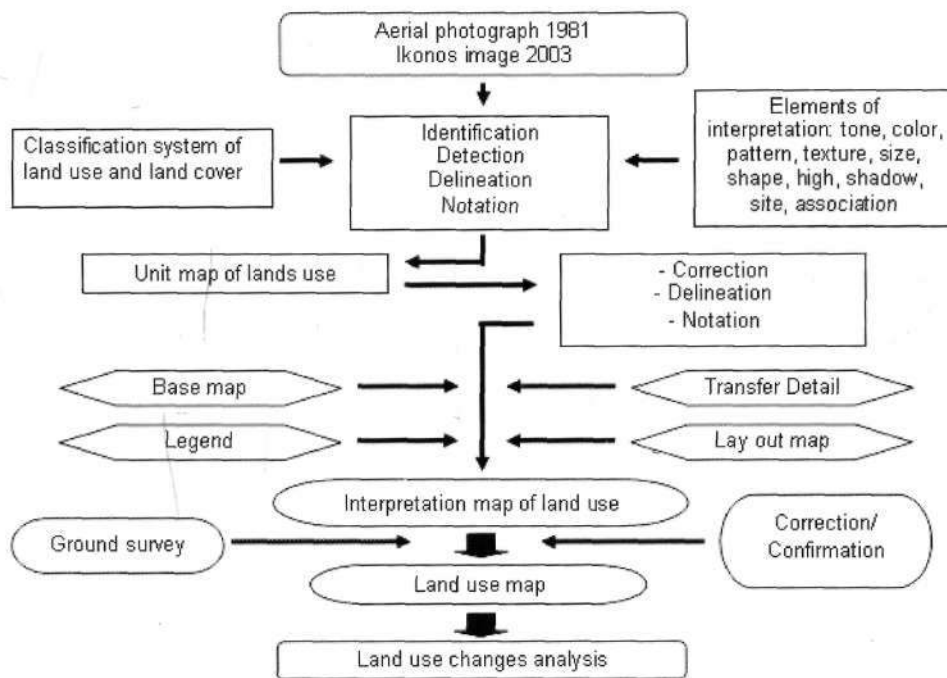


Figure 1. Monitoring land use by interpretation of aerial photograph and Ikonos image

Table 1. Areas of land use types in Bedugul, Bali in 1981 and 2003

No.	Land use	Area (ha)	
		1981	2003
1.	Settlements	126.7	189.3
2.	Dryland	967.1	974.6
3.	Mixed crops	58.9	86.3
4.	Coffee crops	130.8	14.3
5.	Golf course	120.0	120.0
6.	Shrub	237.7	263.9
7.	Protected forest	3748.4	3715.9
8.	Secondary forest	183.3	208.5
9.	Botanical garden	159.2	159.2
10.	Beratan, Buyan and Tamblingan Lakes	1029.4	1029.4
Total		6761.4	6761.4



Figure 2. Aerial photograph of Bedugul, Bali, August 16, 1981

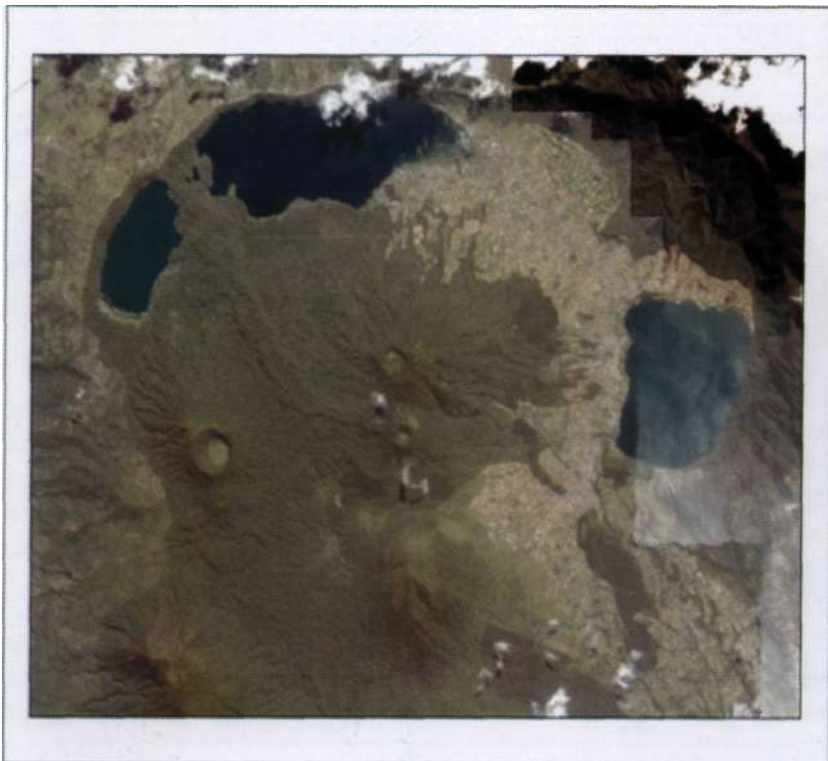


Figure 3. Ikonos image of Bedugul, Bali, May 3, 2003

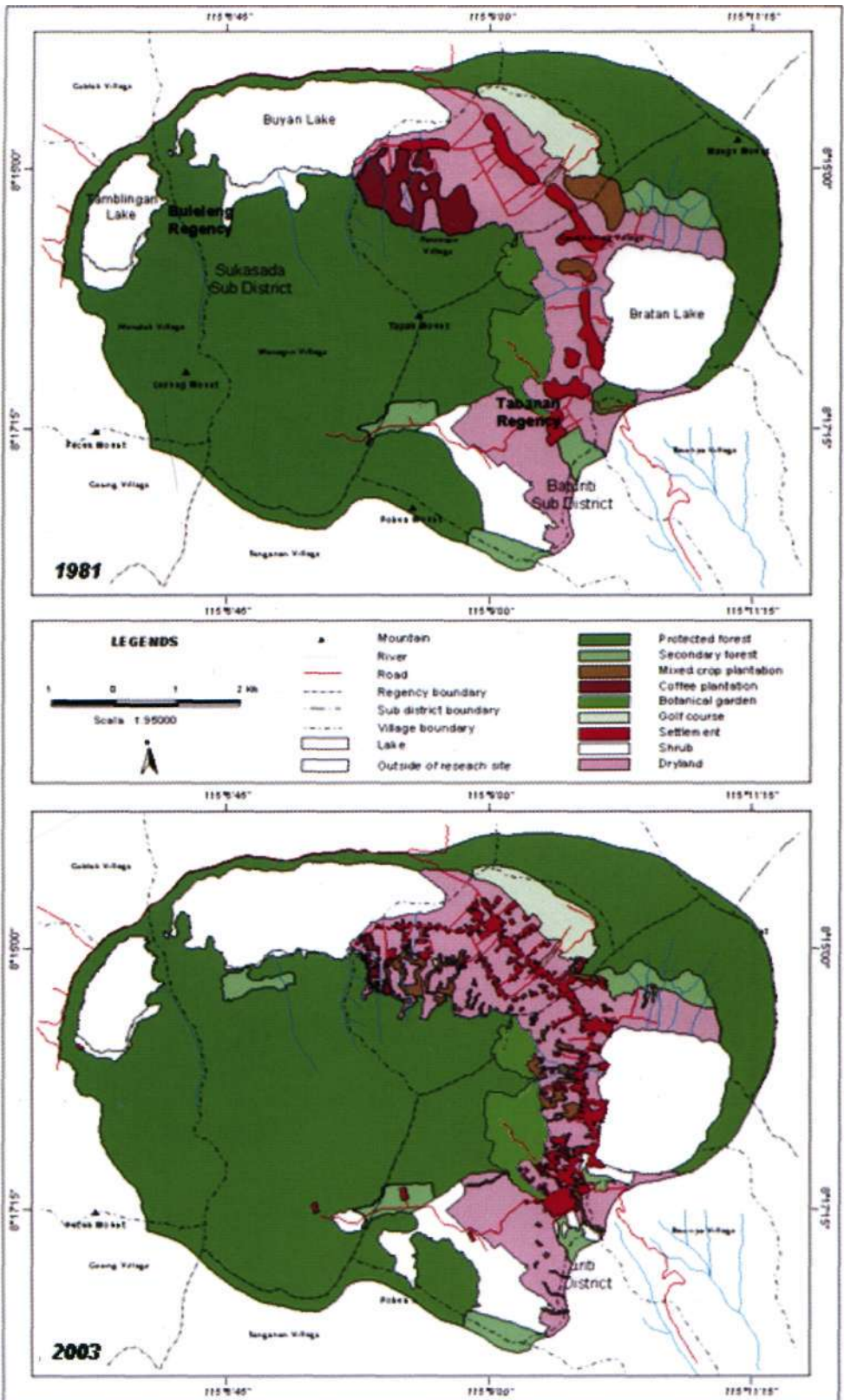


Figure 4 Land use map of Bedugul, Bali on 1981 and 2003



Figure 5. Land use changes in the site of Bukit Berbunga Villas

Energy Ltd. This company plans to drill a well of 13 points spread in the location of 538 ha. The drilling has been done at the foot of Pohen Mountain at the sub-village of Bukitcatu in the Tapak Mountain, in the western part of Eka Karya Botanical Garden Bedugul. Besides for point drilling, this effort also needs area for barrack and store room and entrance road of 15 m wide from the junction of the sub-village of Bukitcatu leading to the project location. The land for the entrance road used to be dryland planted with vegetables by farming of the surrounding village and some used to be part of a forest. Secondary forest increased by 25.2 ha. This is caused by the fact that the bush in the southern part of Buyan Lake has been planted with rasamala trees. In 2003, these plants had grown taller.

Conclusion

There were land use changes in Bedugul, Bali over 22 year of observation (1981-2003). The area of settlement increased by 62.6 ha, dryland vegetable crops increased by 7.5 ha, and shrub increased by 26.2 ha. On the other hand, coffee crops decreased by 116.5 ha, and forest area decreased by 32.5 ha. Therefore, monitoring land use change using remote sensing and GIS technique periodically is needed in order to anticipate uncontrolled land use changes.

References

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