

LAND CHARACTERISTIC AND SUITABILITY IN RELATION TO AGRICULTURAL LAND-USE PLANNING IN DENPASAR, BALI

I Ketut Sardiana

Soil and Environment Departement, Faculty of Agriculture, Udayana University
Jl. PB Sudirman, Denpasar, Bali, Indonesia (80223). ksardiana@yahoo.co.id

Abstract

Eksistensi subak sebagai warisan budaya mulai terancam akibat alih fungsi lahan sawah yang terus meningkat sejalan dengan pesatnya laju pembangunan, terutama di sektor pariwisata. Alternatif yang dapat ditempuh untuk menekan alih fungsi lahan sawah yaitu melalui optimasi penggunaan lahan dengan menerapkan usaha tani bernilai tinggi, seperti hortikultura untuk konsumsi hotel dan tanaman obat. Agar perencanaan pengembangan komoditas pertanian dapat dibuat akurat dan efektif, maka perlu didukung data karakteristik lahan yang lengkap dan mutakhir. Tujuan penelitian ini yaitu untuk mengevaluasi kesesuaian lahan untuk pengembangan komoditas tanaman hortikultura dan obat, dan menyusun arahan pertanian perkotaan berbasis lingkungan, peluang pasar, dan perlindungan subak.

Metode yang digunakan dalam penelitian yaitu survey lapangan dengan subak sebagai unit pengambilan sampel. Sifat-sifat tanah dianalisis dengan metode analisis tanah yang telah baku berlaku di laboratorium. Kelas kesesuaian lahan ditentukan berdasarkan faktor pembatas minimum dengan matching system yaitu membandingkan antara kualitas lahan dengan persyaratan tumbuh tanaman menurut Zainudin, dkk., 1997. Arahan penggunaan lahan disusun berdasarkan kelas kesesuaian lahan tertinggi, konsevasi subak, dan filosofi budaya Bali.

Hasil penelitian menunjukkan, bahwa kesesuaian lahan untuk padi tergolong sangat sesuai (S_1), untuk sayuran, buah-buahan, dan tanaman obat tergolong sesuai (S_2) dengan dua faktor pembatas yaitu drainase buruk dan tekstur tanah halus. Dalam pengelolaan tanaman tersebut diperlukan pembuatan saluran drainase untuk memperbaiki drainase dan penambahan bahan organik untuk memperbaiki tekstur tanah. Arahan penggunaan lahan pertanian di Denpasar, pada musim hujan diprioritaskan untuk bertanam padi mengikuti pola rotasi tanaman dan zonasi penanaman komoditas pertanian, seperti jenis bunga-bunga di bagian utara, jenis buah-buahan dan sayuran di bagian tengah, sayuran dan tanaman palawija di bagian selatan.

Keywords: *karakteristik, kesesuaian, perencanaan penggunaan lahan*

1. Introduction

Subak is an institution regulating rural irrigation, which is very well known internationally, not only by the experts in irrigation but also those of socio-culture. Subak contain philosophical life of the Balinese including water conservation in a watershed (Sutawan, 2008). Further it is emphasized that subak contains the principles of sustainable agricultural

development, because people are dependent upon water resources so all of them must have active participation preserving watershed. Meanwhile, the existence of subak as noble cultural heritage and environment becomes more threatened with the growing increase in tourism activities. Conversion of rice field continues with the process of development especially in the sector of tourism and settlement.

Denpasar is part of Bali with the highest paddy land conversion. The rate of rice field conversion reaches the average of 52 ha/year or 1.58% /year (BPS Kota Denpasar, 2013). This situation occurs because of the need of development especially the rapid development in tourism sector. Besides that, the low price of plant for food commodity also pushes the land conversion. In addition, the land available for urban development in Denpasar is already in the form of rice field while dry land is very limited.

The existence of subak needs to be conserved, although it has low economic value, but it has high value of cultural heritage and environmental value. Therefore, new breakthrough is needed to balance the economic and environmental value. The possible alternative is optimization of agricultural land use through farm business of plant with high values such as horticulture for hotel consumption and medicine. In order that its planning can be done accurately and efficiently, the availability of the information about the physical factor of the environment is needed covering the characteristics and potential of the land (Sitorus, 1985).

The objectives of this study are: to determine land characteristics and land suitability to the economical commodity; to make guidelines of urban agricultural development that is environmentally-based in every unit land management by paying attention to market opportunity, land conservation and the existence of subak.

2. Materials and Method

2.1 Site Study

The area of the municipality of Denpasar covers part of mainland area of Bali Island and all of Serangan Island. Its area is 12,778 ha or around 2.27% of all the area of Bali Province. Geographically the municipality of Denpasar lies between 08°35'31"–08°44'49" South Latitude and 115°10'23"–115°16'27" East Longitude. It is situated between 0–75 m above sea level.

The area of Denpasar was formed from volcanic and marine landform covered by fluvial. Volcanic landform is a volcanic plain that can be found in the northern and the southern part is fluvial landform that covers marine landform. The northern part of Denpasar has gentle and wavy relief while the southern part has level relief.

Most of the topography of Denpasar (82.2%) is plain areas with the slope generally ranges from 0–2% to the south, some has slope between 2 and 8%. Slope in some places especially in the bank of a river can reach 15%.

The kind of soil in the area of Denpasar came from the same litology, as a result of the weathering of volcanic rocks that originated from Buyan–Bratan volcano and Batur volcano and the fluvial deposit found in the south coast. Based on the soil map with the scale of 1 : 250,000 (Yunus Dai, 1971) the kind of soil consists of Yellowish Brown Latosol whose spread occupies almost all of the area of Denpasar except the area by the beach, which is alluvial soil.

2.2 Land Characteristics and Evaluation of land suitability

Land characteristics is another property that can be measured and analyzed (Sitorus, 1985). Land characteristics observed is the property of land that becomes the criteria in the evaluation of land suitability. The location in the field is based on homogeneous land. In this case, the unit taken as a sample is subak. This is based on the assumption that in a subak is thought of as managing homogenous land. 18 out of 46 samples taken were analyzed in the laboratory.

Variables being considered for land suitability for several agricultural commodities were characteristics of the area which include: climate, soil drainage, soil texture, effective soil depth, soil CEC, soil pH, salinity, slope, degree of erosion, incidence of food, and water stagnant. The climate data analysis by classifying the rainfall degree based on Oldeman and Schmidt-Ferguson system. Physical and chemical analysis method is done by a world-class standard and conducted at the Faculty of Agriculture of Udayana University.

The analysis results were evaluated to determine land suitability for commercial commodities. Class or sub class of land suitability is based on matching system between land qualities and crop requirements. Actual and potential land suitability was determined by using criteria given in Technical Guidelines for Land Evaluation for Research Center of Soil and Agroclimates Bogor (Djaenudin, *et. al.*, 1997).

2.3 Guideline for Land Use

Guideline for land use is based on the highest land suitability, conservation of subak land, characteristics of land, the availability of water, and reference of Balinese cultural philosophy.

3. Results and Discussion

3.1. Land Characteristic and Land Suitability

There are three factors for determining the parameter for characteristics and the quality of land evaluated in order for it to be classified as suitable: relief, climate, and soil. The survey in the field and laboratory analysis obtain the following characteristics:

Relief

The land that has been researched sloped with the original slope < 8%. This land has been cultivated, in the form of permanent terrace rice field. Factor of erosion and environmental damage has been overcome through land and water conservation. Therefore, micro slope is actually even so from the aspect of relief it can be categorized as very suitable (S1) for every kind of plant. In other words, according to its relief, agriculture in the municipality of Denpasar has referred to environmentally-based agriculture.

Climate

The climate suitable for the requirements of the evaluation of land suitability consists of temperature and its relation to altitude, rainfall, and air humidity. Based on the requirement of plant growth and data on temperature, it shows that rice, *palawija* crop, water melon, and melon is very suitable (S1) (temperature < 30°C) while horticulture plant in the form of vegetables and flowers are categorized as suitable (S2) (temperature 26°C – 30°C).

On the average, rainfall was normal (based on the data of 10 years period, 1995 – 2005), 2101 mm per year and, and the monthly average rainfall was 175 mm. Wet month (rainfall > 100 mm/month) lasts 7 months and dry month (< 75 mm/ month) lasts 4 months and humid month lasts 2 months. Based on the criterion of the actual land suitability during the 3 – 4 month-growth of plant, for food plant is very suitable (S1) except paddy which needs irrigation water during the dry season. Both *palawija* crop and horticulture plant are very suitable planted in the

beginning of dry season, March or April. In other words, the water availability shows that the land within the municipality of Denpasar can be categorized as very suitable to suitable (300 – 500 mm/month) for all food plant and low land horticulture. This is because during the growing period, it is fulfilled by rainfall and irrigation water. Planting pattern is very important to keep the conservation of subak as the producer of rice and subak conservation as cultural heritage.

The data of air humidity shows that it on the average normal, 81%. Therefore it can be classified as very suitable ($\pm 80\%$) up to suitable ($\pm 20\%$) for all horticulture plants.

Physical characteristics of Soil

The criteria of land suitability for various kinds of plants in terms of land drainage with the field condition and analysis results in the laboratory showed that lands with the subak areas of Denpasar are categorized as having blocked drainage, rather blocked and having rather good drainage. This is caused by the texture of soil which can be categorized as clay, clay loam, loam, and silty clay loam. The same is true with the permeability of soil in the field which belongs to the criteria of slow and rather slow with the range of 0.20 – 1.85 cm/ hour.

Based on land drainage in the field and its permeability, the lands in Subak areas of the southern part of Denpasar can be classified as having rather good drainage while for the lands Subak areas in the western part of Denpasar district in general have rather good to rather blocked drainage. Different from the lands in the northern part of Denpasar district in general the drainage there is blocked and rather blocked. The same is true for the lands in Denpasar east District, they have blocked drainage because it comes from alluvial deposit.

According to the criteria of the classification of land suitability for various kinds of requirements of plant growth, it shows that rice is classified as very suitable (S1). Different from horticulture plant, in general it is classified as marginally suitable (S3), suitable (S2), and very suitable (S1). Lands that have fine texture with the limiting factor of drainage is classified as marginally suitable. This soils can be found in the southern and northeastern part of the municipality of Denpasar. This can be improved by cultivating the soil and drainage canal.

From the aspect of land drainage, subak in the northern part of Denpasar district has high potential to be used as horticulture agriculture, particularly vegetables, melon, and water melon. The requirements needed for these plants are land cultivation, and planted in the end of rainy season.

Chemical Characteristics of Soil

The chemical nature of the soil analyzed is suitable to the criterion of land suitability classification according to Djaenuddin *et al.* (1997) consists of: acidity of soil, CEC, BS and C-organic of the soil. Alkalinity, salinity, and the sulphidic danger are not analyzed because the soil originates from volcanic substance. The results of the analysis of soil in the laboratory from various subaks are presented in Table 3 while the description of each soil characteristic is as follows:

The soil acidity shows that soils in the research area is categorized as acid until neutral with the range

of pH soil, 5.65 – 7.80. Most of the soil (52.3%), 0.03% is categorized as being rather base. And 45.1% are categorized as being rather acid. The soil with base reaction can be found in Subak Cuculan, Sidakarya and Sesetan; the soil in these areas is in the south coastal areas. At such pH condition it is very suitable for every kind of plants either food plants or horticulture plant.

The content of soil organic carbon is needed to keep the balance of the elements and humidity of the soil. The result of the analysis shows that the content of soil organic carbon ranges from being very low to being moderate. Most of the content of soil C organic (51.6%) is categorized as moderate, 39.5% of the content is low, and 8.9% very low. This means that in increasing the products of the farmers the supplement of organic substance is absolutely needed.

The criteria of the Cation Exchange Capacity (CEC) and the base saturation (BS) shows that CEC

Table 1. Chemical and physical properties from various subaks

No	Name of subak	pH(H ₂ O) 1 : 2,5	EC mmhos/cm	Organic C (%)	CEC (me/100g)	BS (%)	Permeability cm/hour	Texture Class
	1	2	3	4	5	6	7	8
1	Pemogan	7.32N	1.20VL	3.19H	51.55 VH	76.92 VH	0.39 SP	Clay
2	Pedungan	7.15N	0.30VL	2.72 M	34.70H	76.11 VH	0.73 SP	Clay
3	Sesetan	7.25N	0.72 VL	2.15 M	33.84H	47.06M	0.62 SP	Clay
4	Sidakarya	7.30N	0.28 VL	1.28L	32.66H	60.87 H	0.41 SP	Clay
5	Panjer	6.43 RA	0.25 VL	1.70L	29.16H	41.79 H	1.46P	Silty Loam
6	Renon	6.90N	0.16VL	1.37L	30.36H	>100 VH	1.42 P	Silt
7	Sanur	6.74N	0.24 VL	0.85 VL	26.08H	63.33 H	0.68 SP	Silty Loam
8	Kesiman	6.46 RA	0.15 VL	1.79L	43.70H	77.67 VH	1.54 P	Silty Loam
9	Kertalangu	6.85N	0.26 VL	2.14 M	26.80H	79.51 VH	0.67 P	Loam
10	Sumerta	6.45 RA	2.60 M	1.28L	29.02 H	48.12 VH	1.89 SP	Loam
11	Dangri Kaja	6.60N	2.10 M	2.28 M	24.75 H	80.19 VH	0.93 SP	Clay Loam
12	Penatih	6.70N	0.28 VL	2.53 M	35.99H	>100 VH	0.57 SP	Clay
13	Pemecutan	7.1 N	0.60L	3.14H	24.41 H	74.99 VH	1.55 P	Clay Loam
14	Dauh Puri	6.61 N	0.18 VL	1.31 L	28.63 H	90.63 VH	1.79 P	Clay Loam
15	Padangsambian	6.82N	0.04 VL	2.31 M	37.51 H	75.80 VH	0.83 P	Silty Loam
16	Ubung	5.99 RA	0.88 VL	1.74L	40.3VH	72.33 H	0.20 SP	Clay
17	Paguyangan	7.00N	0.28 VL	1.72L	30.21 H	54.053 H	1.45 P	Clay
18	Tegal Harum	7.24 RB	0.62 VL	2.19 M	46.5 VH	88.89 VH	0.25 SP	Clay

Appendix : (VL : very low; L: low; M : moderate; H : high; VH : very high; N : neutral; RA : rather Acid; RB : rather base; P : poorly; SP : somewhat poorly)

of the soil ranges from 16.91 me/100g of soil (moderate) to 51.55 me/ 100 g of soil (very high). Most of the CEC in the observation site is categorized as high, 7.2% of the location is categorized as moderate and 7.2% of the location is classified as very high. The base saturation ranges from 21.57% (moderate) up to > 100% (very high). From that range, most of the location (62.1%) of the location has BS which is categorizable as very high, 30.7% of the location has BS categorized as high and only 7.2% of the location has BS that is categorized as moderate. From the data, it can be concluded that the potential of the fertility of land is categorizable as high (Kelti team of Soil Fertilities, 1995).

Recapitulation of the suitability level of land of several commodities of basic food plant and horticulture (vegetable, fruits, flower) and medicinal plants of each subak is presented in Table 4. In this appendix, it shows that all subak areas in Denpasar is very suitable (S₁) for paddy field. Different from the suitability for horticulture plant, there is a limiting factor drainage, soil texture (r), air temperature (t), and or air humidity (w).

The need for water by plant during the growth period of the plant is fulfilled by rainfall and irrigation water. Factor of soil such as CEC and BS, C organic lies in the very suitable range. Therefore, several lowland horticulture plants are potentially suitable (S₂) planted in rice fields, except for chili, banana, and mango which are categorized as suitable.

d. Guideline of Land use

The results of the classification on agro ecosystem of land suitability from several plant commodities and horticulture and medicinal plant is ordered based on the level of its suitability, this is presented in Figure 1.

Besides that it refers to the philosophical concept of Balinese culture, *Tri Hita Karana* and *Tri Mandala* concept. These concepts describes the division of areas based on upper, south, and middle area. According to this concept, flower garden should lie in upper area or in front, fruits in the middle, and trees and house for animal in the back or south area. For Denpasar area, upper area lies in the northern part, middle around the center of the city and southern area lies in coastal area or in the southern part of Denpasar.

For the development of horticulture plant in each subak, land management is needed together

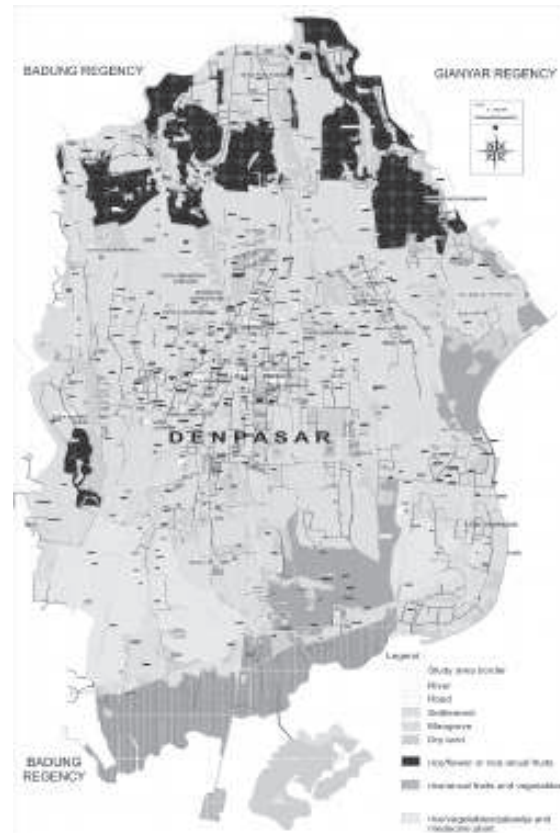


Figure 1. *Guideline of Land use*

with soil cultivation and distribution of organic matter to improve drainage and increasing the land productivity. Drainage is needed to improve the ground drainage. For this purpose, in the rice field area, drainage canalling is needed to avoid the saturation of ground water that can cause the plant roots to decay.

Paddy becomes main commodity, this is intended for keeping the preservation of subak known for its traditional irrigation system. Land use for horticulture commodity is not more than 30% of the whole subak area. The pattern for land use is done by means of plant rotation, mixed farming or subak zoning, the use of subak for some years (maximally for 3 years in succession).

4. Conclusion

It can be concluded as follows:

1. The physical nature of soil in the rice field is very suitable (S₁) for paddy field, sufficiently suitable (S₂) for horticulture plant. The chemical

nature of land categorizable as moderate, North Denpasar area is in general low in fertility, as a result of the intensive use of land and imbalanced fertilization.

2. Land suitability for rice field is categorizable as very suitable (S_1); for vegetable plant, fruits, flower, and herbal plant is categorizable as moderately suitable with limiting factors of slow drainage and fine texture of soil. To improve the land can be done by soil cultivation, the provision of drainage canal, and fertilization based on the dosage needed.
3. Allocation of land use in Denpasar must be made in rainy season especially for rice field. Through the pattern of plant rotation such as the centers for flowers in North Denpasar, center for fruits and vegetables in the central part of Denpasar, vegetable and *palawija* crop in southern part of Denpasar. This allocation is based on the conservation of subak land, soil characteristic, the availability of water, and reference of the philosophy of Balinese culture. (*Tri Angga* and *Tri Mandala* concept).

Acknowledgements

We express our gratitude to Prof. Indayati Lanya and staf of soil laboratory faculty of Agriculture The University of Udayana who supported the facilities for this study.

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