

## Short Communication: Plant diversity utilization and land cover composition in the Subak Jatiluwih, Bali, Indonesia

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**Abstract.** *Sutomo, Iryadi R, Darma ID, Wibawa IPAH, Rahayu A, Hanum SF, Rizal S, Novamizanti L, Raharjo J. 2021. Short Communication: Plant diversity utilization, and land cover composition in the Subak Jatiluwih, Bali, Indonesia. Biodiversitas 22: 1424-1432.* Subak is water management or irrigation system for paddy fields in Bali Island and it has been assigned as a UNESCO's World Heritage Site. At a landscape level, it comprises several components which are forests, terraced paddy landscape, rice fields, villages and temples. Subak in Jatiluwih Village, Tabanan Regency depicts an areacharacterized by its natural appearance in the form of a vast rice valley with a dike in stratum following its natural contours (frequent terraces). This paper aimed to explore plant diversity in various vegetations around Subak Jatiluwih as well as their usage in the daily living of the local community. We also explore the potential application of drone for classifying the landscape patterns of the Subak. Vegetation sampling to record plant diversity was done using purposive sampling, and drone or Unmanned Aerial Vehicle (UAV) was used to map the Subak Jatiluwih landscape. The potential usage of each species was obtained through interview with key respondents, and the level of usage of each species was analyzed using the BIV (Benefit Index Value). *Tegalan* area shows the highest number plant diversity in Subak Jatiluwih area. Furthermore, there are four species of plants that have the highest BIV namely: *Cocos nucifera* L., *Psidium guajava* L., *Areca catechu* L. and *Musa × paradisiaca* L.. Various plant uses by the locals include for animal feed, building, ceremony, craft, and food and medicinal purposes. The landscape in Subak Jatiluwih is dominated the vast valley of rice fields that has strata following its natural contours. These conditions provide opportunities to applied the conservation strategy based on cultural and custom values.

**Keywords:** Rice field, species diversity, culture, conservation

### INTRODUCTION

The water management or irrigation system for paddy fields in Bali Island is known as Subak. Subak is characterized by ecologically sustainable system-managed under strong Balinese culture. It connects Balinese agricultural management together within the village's *Bale Banjar* community center and Balinese temples. Management of the water is under the leadership of a chosen farmer, a priest that practices the *Tri Hita Karana* Philosophy, which is a self-described relationship between humans, the earth, and the Gods (Lansing 1987; Wardana 2020). Sutawan (2004) states that the elements of *Tri Hita Karana* are represented in the *subak* temple hierarchy and the rituals performed (*parahyangan*), the irrigation network, and paddy fields, including fauna and flora (*palemahan*), and the *subak* organization and rules (*pawongan*).

The word '*subak*' is considered as the modern form of the word '*suwak*'. *Suwak* is found in the Pandak Badung Inscription (1071) and Klungkung inscription (1072). *Suwak* comes from two words, namely '*su*' which means good and '*wak*' which means watering. Thus, *suwak* can be interpreted as a good irrigation system (Mulyati, 2019). Etymologically, '*Subak*' refers to a unique social and

religious institution, has its own arrangements, associations democracy of farmers in determining the use of irrigation water for rice growing agriculture. In practice, however, Subak for the people of Bali is not just an irrigation system, but also a concept of life for the people of Bali itself. In the view of the Balinese, Subak is a direct illustration of the *Tri Hita Karana* philosophy (Wardana 2020). As a method of structuring life together, Subak has been able to survive for more than a century because its people are obedient to ancestral traditions (Chong and Lai 2018) and The Subak has particular interest because of their sustainability in managing nature, human, and culture for more than a millennium (Surata and Vipriyanti 2018)

Subak comprises several landscape components, namely: forests, terraced paddy landscape, rice fields, villages, and temples. The forest protects the water supply, the terraced rice field landscape is connected by a system of canals, tunnels, and dams while the existence of temples of various sizes indicates the importance of water sources or the passage of water through the temples downhill to irrigate Subak lands. Bali has about 1,200 *subaks* (Salamanca et al., 2015). Until 2016, the total area of rice fields managed by the Subak community throughout Bali was 78,000 hectares (Bappeda Provinsi Bali 2015). The

area of the subak area is very dependent on the ability of a water source to irrigate a certain land. The number of springs in Bali is recorded at 547 with a total water discharge of 13.4m<sup>3</sup>/second or 422.59 million m<sup>3</sup>/year. Other sources of water come from rainfall, which is 7,465.83 million m<sup>3</sup>/year, as well as from rivers, groundwater, and others. In terms of number (percentage), the water demand in Bali is sufficient to irrigate the rice fields in Bali. The main infrastructure component in Subak is the irrigation network. The main facilities for subak irrigation (*palemahan*) for each subak member are *pengalapan* (water dam), *jelinjing* (ditch), and *cakangan* (a place/tool to enter water into processed rice fields/ fields) (Windia, 2010). The water from springs and canals flows through the temples that have been managing of water resource by a group of Subak (Rahmi and Setiawan 2020)).

Because of its ecological and socio-cultural uniqueness, Subak system was then internationally recognized as a world heritage site by UNESCO on 6 July, 2012 (Chapman 2017). One of the most popular Subak systems in Bali is located in Jatiluwih Village, Tabanan Regency where becomes a magnet for tourists in Bali to visit it, especially foreign tourists (Rahmi and Setiawan 2020). Landscape in Subak Jatiluwih depicts an area characterized by its natural appearance in the form of a vast rice valley with a dike in stratum following its natural contours (frequent terraces). On the paddy field, there are six patches of landscape in the form of vegetation cover, namely paddy fields, *Pura Bedugul* (A special temple built by farmers and landowners intended for *Dewi Sri* as the goddess of prosperity and fertility), huts, dry fields, footpaths and river basins (DAS).

Subak system has attracted studies from various fields; one of them is spatial ecology. Taking benefits from the advancing technology, monitoring and study of vegetation can now be conducted in a spatially explicit manner using aerial photographic data and satellite imagery. Some monitoring studies in their development at this time require a technology that is fast and accurate in which periodical data can be acquired. One of the tools that can currently be relied upon is the use of drone technology in which we are able to use this tool without having to wait until daily or weekly. Currently, researchers are exploring the uses of drone technology and satellite imagery data for monitoring landscape and agricultural land, for example monitoring the growth development of rice to estimate its productivity, and other agricultural purposes ( Dharmiasih and Arbi, 2018; Marsujitullah and Kaligis 2019; Inoue 2020).

In this paper, we elaborate on plant diversity in various vegetations around Subak Jatiluwih as well as their usage in the daily living of the local community. We also explore the potential application of drones for classifying the landscape patterns of the Subak. This information is expected to be a reference in the management of Subak Jatiluwih.

## MATERIALS AND METHODS

### Study area and period

The study was conducted in Subak Jatiluwih in March 2020 (Figure 1). Jatiluwih Subak is located at the foot of

Batukaru Mountain, Jatiluwih Village, Penebel District, Tabanan Regency, Bali, Indonesia. Jatiluwih Village is ± 26 km to the north of Tabanan Regency or ± 13 km to the north of Penebel District and 49 km to the capital of the Bali Province. Jatiluwih village lies at an altitude of approximately 685 m above sea level, with an average temperature of 26-29<sup>0</sup>C with humidity of 75-90%. Jatiluwih Village has a tropical climate with the rainy season from October to March and the dry season from April to September (Artanegara 2019). Village boundary area of Jatiluwih is as follows: the north side is bordered with protected forest, the east side is Senganan village while on the south side is Babahan Village and on the west side is bordered with Wongaya Gede Village.

Overall, the size area of Subak Jatiluwih is 348 ha. Jatiluwih Subak is divided into seven sub-subaks or *tempek*, with the length of the irrigation channel from the water source to the rice fields per farmer reaching 33,383 m. These *tempek* include the Telede Gede Subak Tempek, Besikalung Subak Tempek, Kedamean Subak Tempek, Uma Duwi Subak Tempek, Kesambi Subak Tempek, Gunung Sari Subak Tempek, and Gunung Uma Subak Tempek. Irrigation water sources in Jatiluwih Subak are obtained from springs, waterfalls, and several rivers that cross Jatiluwih Subak such as the *Yeh Ho* River, the *Yeh Baat* River, the Munduk Abangan River, and the *Yeh Pusut* River (Wardana 2020). Then, Artanegara (2019) proposes that the four rivers of the Ho Ho River irrigate the Umakayu subak, the *Yeh Baat* River irrigate the Jatiluwih subak, Kedamean and Kalungbesi, the Munduk Abangan River irrigate the Gunung Sari subak and the *Yeh Pusut* River irrigate the Kesambi subak.

### Data collection

Vegetation sampling was done with purposive sampling, which was carried out on six areas includes *tegalan* (land fields), *daerah aliran sungai/DAS* (river flow areas), *papagan sawah* (rice fields), *pura* (temples), *jalan setapak* (walkways) and *pondok* (huts). Papagan rice field is an area on the edge of a paddy field that cannot be planted with rice. Pondok is a place for raising livestock. Roads are corridors of subak members.

Herbarium voucher was collected and then identified at the *Hortus Botanicus Baliensis*. Potential usage of each species by the community was obtained by interviewing key persons such as *banten* handyman (*banten* is an offering made to God), *pandita*, and housewives.

### Data analysis

Data were analyzed using the BIV (Benefit Index Value)with the equation as follow(Hoffman and Gallaher 2007; Phillips and Gentry 1993):

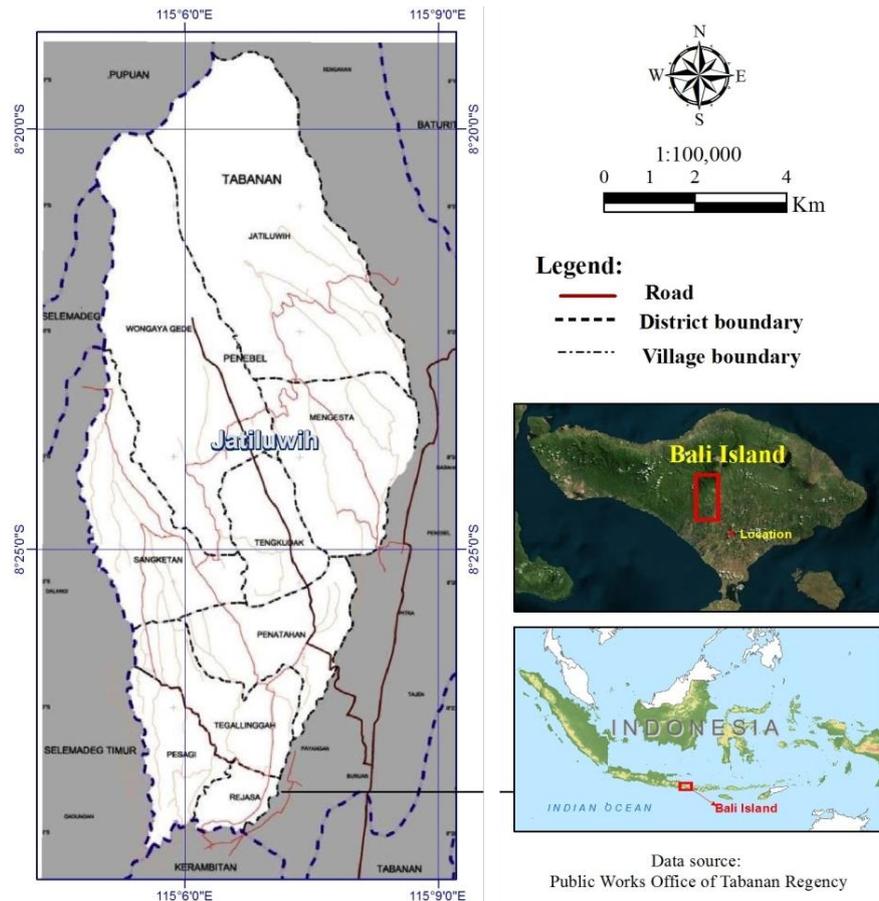
$$BIV = \frac{RF_{sj}}{RFt_{sj}} \times 100 \%$$

Where:

BIV : Usage and abundance Index of A species

RF sj : Relative Frequency of a species

RFt sj : Total relative frequency of a species



**Figure 1.** Study location in the Subak Jatiluwi, Tabanan, Bali, Indonesia

In addition, Unmanned Aerial Vehicle (UAV) or drone (Mavic 2 Pro) was used to capture the aerial view of landscape of the Subak Jatiluwi. Mapping data were recorded using drones in parts of Jatiluwi's rice fields to see the detail the proportion of land cover/use classes in an area of 3.8 ha.

## RESULTS AND DISCUSSION

The diversity of plants in several types of vegetation cover in Subak Jatiluwi area can be seen in Table 1. *Tegalan* area has the highest number of species with 33 species, followed by *daerah aliran sungai/ DAS* with 24 species, and also there are 21 species at *papagan sawah*, 15 species at temple areas, 12 species at *jalan setapak*, and 10 species at *pondok* areas. Ten plant species have high abundance index values, which are *Cocos nucifera* L./ *Kelapa* (5.22) followed by *Psidium guajava* L./ *Sotong* (4.35), *Areca catechu* L./ *Buah* (4.35), *Musa × paradisiaca* L./ *Banana* (3.48), *Artocarpus integer* (Thunb.) Merr./ *Jackfruit* (3.48), *Antidesma bunioides* (L.) Spreng./ *Boni* (3.48), *Cordyline terminalis* (L.) Kunth/ *Andong gadang* (2.61) *Plumeria acuminata*/ *Jepun* (2.61), *Gliricidia sepium*/ *Gamal* (2.61) and *Persea americana*/ *Apokat* (2.61).

There are 107 species of plants utilized by the communities around the Jatiluwi Subak area. From these, 70 species are used for ceremonies, 49 species for food, 26

species for medicinal purposes, 11 species for building materials, 9 species for animal feed and for crafts there are 5 species (Table 2).

In this study, ten plant species that have the highest benefit index are *Musa × paradisiaca* L./ *Pisang* (2.94), followed by *Cocos nucifera* L./ *Kelapa* (2,94), *Arenga pinnata* (Wurmb) Merr./ *Jake* (2,35), *Artocarpus integer* (Thunb.) Merr./ *Nangka* (2,35), *Schizostachyum brachyckadum* (Kurz) Kurz/ *Tiing tali* (1.76) and *Zea mays* L./ *Jagung* (1.76). *Dendrocalamus asper* (Schult.f.) Backer ex Heyne/ *Petung* (1.76), *Aleurites moluccana* (L.) Willd./ *Tingkih* (1.76) and *Moringa oleifera*/ *Moringa* (1.18). Balinese culture and plants seem inseparable, as their ceremonies and traditions are always made use of a variety of plants as well as for their traditional medication known as the *Usada Bali*. The local people in Jatiluwi know 26 plant species that are used for medicinal purposes. This figure is lower than in Bedugul, Bali in which the local people use 69 species (Oktavia et al. 2019), but higher than average indigenous groups in Bali which generally have more than 10 species of medicinal plants that are planted in the area of the yard (Sujarwo and Caneva 2015). Some traditional villages in Bali have experienced cultural erosion, one of which is marked by a decline in ethnobotanical knowledge. One important factor causing cultural erosion is the influence of foreign cultures from developed countries in ecotourism areas (Sujarwo et al. 2014).

**Table 1.** Plant diversity in various vegetation covers in Subak Jatiluwih, Bali, Indonesia

Species name/ local name	Vegetation type					DAS	FR	BIV
	Papagan sawah	Pura	Pondok	Tegalan	Jalan setapak			
<i>Acalypha</i> sp./ <i>Plawa</i>	1	1					2	1.74
<i>Albizia</i> sp./ <i>Belalu</i>				1		1	2	1.74
<i>Amomum</i> sp./ <i>Bongkot</i>			1	1			2	1.74
<i>Antidesma bunius</i> (L.) Spreng./ <i>Boni</i>			1	1	1	1	4	3.48
<i>Areca catechu</i> L./ <i>Buah</i>				2	2	1	5	4.35
<i>Arenga pinnata</i> (Wurmb) Merr./ <i>Jake</i>				1		1	2	1.74
<i>Artocarpus integer</i> (Thunb.) Merr./ <i>Nangka</i>	1	1		1		1	4	3.48
<i>Bambusa vulgaris</i> Ness/ <i>Tiing apel</i>						1	1	0.87
<i>Kaempferia galanga</i> L./ <i>Cekuh</i>			1				1	0.87
<i>Cajanus cajan</i> (L.) Huth./ <i>Undis</i>	1						1	0.87
<i>Capsicum annuum</i> L./ <i>Tabia</i>			1	1			2	1.74
<i>Citrus</i> sp./ <i>Jeruk</i>			1	1			2	1.74
<i>Caladium</i> sp./ <i>Keladi</i>				1		1	2	1.74
<i>Cocos nucifera</i> L./ <i>Kelapa</i>	1	1	1	1	1	1	6	5.22
<i>Codiaeum variegatum</i> (L.) Rumph.ex A.Juss./ <i>Puring</i>		1					1	0.87
<i>Cordyline terminalis</i> Kunth/ <i>Andong gadang</i>		1		1	1		3	2.61
<i>Cordyline fruticosa</i> (L.) A. Chev./ <i>Adong</i>	1	1					2	1.74
<i>Curcuma longa</i> L./ <i>Kunyit</i>	1			1			2	1.74
<i>Cymbopogon nardus</i> (L.) Rendle/ <i>Sere</i>	1	1		1			3	2.61
<i>Debregeasia longifolia</i> (Burm.f.) Wedd./ <i>Sia-sia</i>						1	1	0.87
<i>Dendrocalamus asper</i> (Schult.f.) Backer/ <i>Tiing petung</i>				1		1	2	1.74
<i>Durio zibethinus</i> L./ <i>Doren</i>				1			1	0.87
<i>Erythrina crista-galli</i> L./ <i>Canging</i>		1		1			2	1.74
<i>Ficus benjamina</i> L./ <i>Beringin</i>						1	1	0.87
<i>Ficus drupacea</i> Thunb./ <i>Bunut</i>						1	1	0.87
<i>Gardenia jasminoides</i> J.Ellis/ <i>Jempiring</i>					1		1	0.87
<i>Gigantochloa nigrociliata</i> (Buse) Kurz/ <i>Tiing Tabah</i>						1	1	0.87
<i>Gliricidia sepium</i> (Jacq.) Steud/ <i>Gamal</i>	1			1		1	3	2.61
<i>Graptophyllum pictum</i> (L.) Griff./ <i>Temen</i>		1					1	0.87
<i>Hibiscus rosa-sinensis</i> L./ <i>Pucuk</i>	1	1			1		3	2.61
<i>Hibiscus tiliaceus</i> L./ <i>Waru</i>	1						1	0.87
<i>Languas galanga</i> (L.) Willd./ <i>Isen</i>	1			1			2	1.74
<i>Leucaena leucocephala</i> (Lam.) de Wit./ <i>Lamtoro</i>	1						1	0.87
<i>Malvaviscus</i> sp./ <i>Waru</i>	1					1	2	1.74
<i>Mangifera indica</i> L./ <i>Mangga</i>				1		1	2	1.74
<i>Michelia campaca</i> L./ <i>Cempaka kuning</i>				1		1	2	1.74
<i>Melia azedarach</i> L./ <i>Gempinis</i>				1		1	2	1.74
<i>Morinda citrifolia</i> L./ <i>Tibah</i>	1				1		2	1.74
<i>Muntingia calabura</i> L./ <i>Singepur</i>			1				1	0.87
<i>Musa × paradisiaca</i> L./ <i>Pisang</i>	1		1		1	1	4	3.48
<i>Musa brachycarpa</i> Backer/ <i>Biu Batu</i>				1		1	2	1.74
<i>Nephelium lappaceum</i> L./ <i>Buluan</i>				1			1	0.87
<i>Persea americana</i> Mill./ <i>Apokat</i>	1			1	1		3	2.61
<i>Phyllanthus buxifolius</i> (Blume) Mull.Arg./ <i>Sisih</i>	1	1					2	1.74
<i>Pleomele angustifolia</i> (Medik.) N.E.Br. / <i>Kayu sugih</i>	1	1					2	1.74
<i>Plumeria acuminata</i> W.T.Aiton/ <i>Jepun</i>		1		1	1		3	2.61
<i>Psidium guajava</i> L./ <i>Setong</i>	1		1	1	1	1	5	4.35
<i>Punica granatum</i> L./ <i>Delima</i>		1					1	0.87
<i>Saccharum officinarum</i> L./ <i>Tebu</i>		1		1			2	1.74
<i>Salacca edulis</i> Reinw./ <i>Salak</i>				1			1	0.87
<i>Schefflera elliptica</i> (Blume) Harms/ <i>K. Tulak</i>	1						1	0.87
<i>Schizostachyum brachycladum</i> (Kurz)Kurz/ <i>Tiing tali</i>				1		1	2	1.74
<i>Schizostachyum brachycladum</i> (Kurz ex Munro) Kurz/ <i>Tiing buluh</i>						1	1	0.87
<i>Sesbania grandiflora</i> (L.) Poir./ <i>Tuwi</i>						1	1	0.87
<i>Syzygium aromaticum</i> (L.) Merr.& L.M.Perry/ <i>Cengkeh</i>				1			1	0.87
<i>Vitex trifolia</i> L./ <i>Liligundi</i>	1			1			2	1.74
<i>Zingiber officinale</i> Roscoe/ <i>Jahe</i>			1	1			2	1.74
Total	21	15	10	33	12	24	115	100

**Table 2.** Plant species that are used by locals around Jatiluwih Village in Bali, Indonesia and their usage and abundance index

Species name / local name	Usage						FR	BIV
	A	B	Ce	Cr	F	M		
<i>Acorus calamus</i> L./ <i>Jangu</i> *			1			1	2	1.18
<i>Albizia chinensis</i> (Osbeck) Merr./ <i>Sengon</i> *		1					1	0.59
<i>Aleurites ambinix</i> Pers./ <i>Tingkih</i> *			1		1	1	3	1.76
<i>Allium cepa</i> L./ <i>Kesuna</i> *					1	1	2	1.18
<i>Allium sativum</i> L./ <i>Bawang</i> *					1	1	2	1.18
<i>Ananas comosus</i> (L.) Merr./ <i>Nanas</i> *			1		1		2	1.18
<i>Annona muricata</i> L./ <i>Sirsak</i> *					1	1	2	1.18
<i>Arenga pinnata</i> (Wurmb) Merr./ <i>Jake</i> *		1	1	1	1		4	2.35
<i>Artocarpus altilis</i> (Parkinson) Fosberg/ <i>Sukun</i> *			1		1		2	1.18
<i>Artocarpus integer</i> (Thunb.) Merr./ <i>Nangka</i> *	1	1	1		1		4	2.35
<i>Baccaurea racemosa</i> (Reinw.) Müll.Arg./ <i>Kepundung</i> *			1		1		2	1.18
<i>Bougainvillea spectabilis</i> Willd./ <i>Kembang kertas</i> *			1				1	0.59
<i>Caesalpinia pulcherrima</i> (L.) Sw./ <i>Kemerakan</i> *			1				1	0.59
<i>Cajanus cajan</i> (L.) Huth./ <i>Kacang undis</i> *			1		1		2	1.18
<i>Calamus</i> sp./ <i>Penyalin</i> *			1	1			2	1.18
<i>Calliandra</i> sp.1/ <i>Kaliandra</i> *	1						1	0.59
<i>Calliandra</i> sp.2/ <i>Kaliandra</i> *	1						1	0.59
<i>Calotropis gigantea</i> (L.) W.T.Aiton/ <i>Maduri</i> *			1				1	0.59
<i>Cananga odorata</i> (Lam.) Hook.f. & Thomson/ <i>Sandat</i> *			1				1	0.59
<i>Capsicum annuum</i> L./ <i>Tabia</i> *					1		1	0.59
<i>Caryota mitis</i> Lour./ <i>Uduh</i> *			1				1	0.59
<i>Centella asiatica</i> (L.) Urb./ <i>Kepiduh</i> *						1	1	0.59
<i>Citrus × aurantifolia</i> (Christm.) Swingle/ <i>Jeruk lengis</i> *			1			1	2	1.18
<i>Citrus limon</i> (L.) Osbeck/ <i>Lemo</i> *					1		1	0.59
<i>Clitoria ternatea</i> L./ <i>Teleng putih</i> *			1				1	0.59
<i>Cocos nucifera</i> L./ <i>Kelapa</i> *		1	1	1	1	1	5	2.94
<i>Cordyline fruticosa</i> (L.) A. Chev./ <i>Kayu sugih</i> *			1		1		2	1.18
<i>Cordyline terminalis-bicolor</i> / <i>Andong bang</i> *			1				1	0.59
<i>Crassocephalum crepidioides</i> (Benth.) S. Moore/ <i>Kejelengotan</i> *					1		1	0.59
<i>Curcuma aeruginosa</i> Roxb./ <i>Temu Ireng</i> *			1			1	2	1.18
<i>Curcuma longa</i> L./ <i>Jahe</i> *						1	1	0.59
<i>Curcuma</i> sp.1/ <i>Temu konci</i> *						1	1	0.59
<i>Curcuma</i> sp.2/ <i>Temu tis</i> *			1			1	2	1.18
<i>Curcuma</i> sp.3/ <i>Temu gongseng</i> *			1				1	0.59
<i>Curcuma</i> sp.4/ <i>Temu poh</i> *			1				1	0.59
<i>Curcuma</i> sp.5/ <i>Temu agung</i> *			1				1	0.59
<i>Cymbopogon citratus</i> (DC.) Stapf/ <i>Sere</i> *					1		1	0.59
<i>Cynodon dactylon</i> (L.) Pers./ <i>Padang lepas</i> *			1				1	0.59
<i>Dendrocalamus asper</i> (Schult.f.) Backer/ <i>Tiing petung</i> *		1	1		1		3	1.76
<i>Dioscorea hispida</i> Denntz./ <i>Sekape</i> *			1		1		2	1.18
<i>Diplazium esculentum</i> (Retz.) Sw/ <i>Paku jukut</i> *					1		1	0.59
<i>Diplazium polypodioides</i> Blume/ <i>Paku kedis</i> *					1		1	0.59
<i>Dolichos lablab</i> L./ <i>Kare</i> *			1		1		2	1.18
<i>Durio zibethinus</i> L./ <i>Duren</i> *			1		1		2	1.18
<i>Elaeocarpus grandiflorus</i> Sm./ <i>Rijasa</i> *			1				1	0.59
<i>Erythrina subumbrans</i> (Hassk.) Merr./ <i>Dadap</i> *			1			1	2	1.18
<i>Euchresta horsfieldii</i> (Lesch.) Benn./ <i>Purnajiwa</i> *						1	1	0.59
<i>Ficus benjamina</i> L./ <i>Beringin</i> *			1				1	0.59
<i>Foeniculum vulgare</i> Mill./ <i>Adas</i> *			1			1	2	1.18
<i>Garcinia mangostana</i> Linn./ <i>Mangis</i> *			1		1		2	1.18
<i>Gardenia jasminoides</i> J.Ellis/ <i>Jempiring</i> *			1				1	0.59
<i>Gigantochloa</i> sp./ <i>Tiing tamplang kuning</i> *			1				1	0.59
<i>Gossypium herbaceum</i> L./ <i>Kapas</i> *			1				1	0.59
<i>Graptophyllum pictum</i> (L.) Griff./ <i>Temen</i> *			1				1	0.59
<i>Hibiscus rosa-sinensis</i> L./ <i>Pucuk</i> *			1				1	0.59
<i>Hoya macrophylla</i> Blume/ <i>Don tebal tebal</i> *			1				1	0.59
<i>Hydrangea macrocarpa</i> Hand.-Mazz./ <i>Panca warna</i> *			1				1	0.59
<i>Jasminum sambac</i> (L.) Aiton/ <i>Menuh</i> *			1				1	0.59
<i>Kaempferia galanga</i> L./ <i>Cekuh</i> *					1	1	2	1.18
<i>Languas galanga</i> (L.) Stuntz/ <i>Isen</i> *					1	1	2	1.18
<i>Lansium domesticum</i> Corrêa/ <i>Croring</i> *			1		1		2	1.18
<i>Leucaena leucocephala</i> (Lam.) de Wit/ <i>Lamtoro</i> *	1						1	0.59
<i>Lindera polyantha</i> (Blume) Boerl./ <i>Adis</i> *		1					1	0.59

<i>Macropanax dispermus</i> (Blume) Kuntze/ <i>Jembrak jaran</i> *				1		1	0.59
<i>Mangifera caesia</i> Jack/ <i>Wani</i> *		1		1		2	1.18
<i>Mangifera indica</i> L./ <i>Poh</i> *		1		1		2	1.18
<i>Manglietia glauca</i> Blume/ <i>Kepelan</i> *	1					1	0.59
<i>Manilkara zapota</i> (L.) P.Royen/ <i>Sabo</i> *		1		1		2	1.18
<i>Michelia × alba</i> DC./ <i>Cempaka putih</i> *		1				1	0.59
<i>Michelia champhaca</i> L./ <i>Cempaka kuning</i> *	1					1	0.59
<i>Momordica charantia</i> L./ <i>Paye</i> *		1		1		2	1.18
<i>Moringa oleifera</i> Lam./ <i>Kelor</i> *				1	1	2	1.18
<i>Musa × paradisiaca</i> L./ <i>Pisang</i> *	1	1	1	1	1	5	2.94
<i>Myristica fragrans</i> Houtt./ <i>Jebugarum</i> *		1			1	2	1.18
<i>Nephelium lappaceum</i> L./ <i>Buluan</i> *		1		1		2	1.18
<i>Nerium oleander</i> L./ <i>Kenyari</i> *		1				1	0.59
<i>Nymphaea</i> sp./ <i>Tunjung</i> *		1				1	0.59
<i>Oryza sativa</i> L./ <i>Padi</i> *	1			1		2	1.18
<i>Paederia foetida</i> L./ <i>Kesimbukan</i> *				1		1	0.59
<i>Pandanus amaryllifolius</i> Roxb./ <i>Pandan arum</i> *		1		1		2	1.18
<i>Pandanus</i> sp./ <i>Pandan meduwi</i> *		1				1	0.59
<i>Phaseolus radiatus</i> L./ <i>Kacang hijau</i> *		1		1		2	1.18
<i>Phaseolus vulgaris</i> L./ <i>Kacang merah</i> *		1		1		2	1.18
<i>Phyllanthus buxifolius</i> (Blume) Müll.Arg./ <i>Kayu sisih</i> *		1				1	0.59
<i>Piper betle</i> L./ <i>Base</i> *		1			1	2	1.18
<i>Piper nigrum</i> L./ <i>Mica</i> *		1		1		2	1.18
<i>Piper</i> sp./ <i>Tabia bun</i> *		1			1	2	1.18
<i>Piper</i> sp./ <i>Don sabo</i> *				1		1	0.59
<i>Punica granatum</i> L./ <i>Delima</i> *		1		1		2	1.18
<i>Rosa</i> sp./ <i>Mawar</i> *		1				1	0.59
<i>Saccharum officinarum</i> L./ <i>Tebu</i> *		1				1	0.59
<i>Salacca edulis</i> Reinw./ <i>Salak</i> *		1		1		2	1.18
<i>Sanchezia nobilis</i> Hook.f./ <i>Temen poleng</i> *	1					1	0.59
<i>Saurauia bracteosa</i> DC./ <i>Yeh-yeh</i> *	1					1	0.59
<i>Sauropus androgynus</i> (L.) Merr./ <i>Kayu mani</i> *				1	1	2	1.18
<i>Schizostachyum brachycladum</i> (Kurz) Kurz/ <i>Tiing tali</i> *	1	1	1			3	1.76
<i>Sechium edule</i> (Jacq.) Sw./ <i>Jepang</i> *				1		1	0.59
<i>Selaginella</i> sp./ <i>Cakar ayam</i> *					1	1	0.59
<i>Sida rhombifolia</i> L./ <i>Siligui</i> *					1	1	0.59
<i>Solanum torvum</i> Sw./ <i>Tuang kokak</i> *				1		1	0.59
<i>Syzygium polyanthum</i> (Wight) Walp./ <i>Jangar ulam</i> *	1			1		2	1.18
<i>Tagetes erecta</i> L./ <i>Gumitir</i> *		1				1	0.59
<i>Tephrosia</i> sp./ <i>Sudamala</i> *		1				1	0.59
<i>Toona sureni</i> (Blume) Merr./ <i>Suren</i> *	1					1	0.59
<i>Trevesia sundaica</i> Miq./ <i>Pelendo</i> *				1		1	0.59
<i>Zea mays</i> L./ <i>Jagung</i> *	1	1		1		3	1.76
<i>Zingiber officinale</i> Roscoe/ <i>Jahe</i> *		1			1	2	1.18
Total	9	11	70	5	49	26	170

Note: \*: Local name, A: Animal feed, B: building, Ce: Ceremony, Cr: Craft, F: Food, M: Medicine

Mapping data using drones in Jatiluwih's rice fields aimed to see the proportion of land cover or land uses in a sampling area of 3.8 ha. From landscape ecology perspective, Subak Jatiluwih landscape consists of fragments, matrix and corridors. Fragment is a homogenous area that can be differentiated from the surrounding area, while matrix is the dominant fragment in landscape, and corridor is a long fragment (Forman and Godron 1986). The fragments in Subak Jatiluwih are mixed gardens, bare fields (*papagan*), *palawija*, herb field, temple, house; while the matrix is rice fields; and the corridors are road and talun along riverside (Figure 3). *Papagan* paddy field is an area on the edge of a rice field that cannot be planted with paddy (Figure 4). This land

indicates conditions that were originally agricultural land and then considered less productive. *Papagan* can be distinguished based on land patterns close to rice fields and conditions in the form of empty land, grass and shrubs scrub or a combination of these covers.

Jatiluwih rice fields use irrigation water following Subak system (Komin and Sedana 2019). In the design of the rice fields, it pays close attention to the irrigation system with a combination of terracing concepts because this area has less flat topography. Similar to rice farming in most Indonesia, the community in Jatiluwih limits ownership of their rice fields, making the area of each rice field of each farmer is not uniform (Macrae 2011).

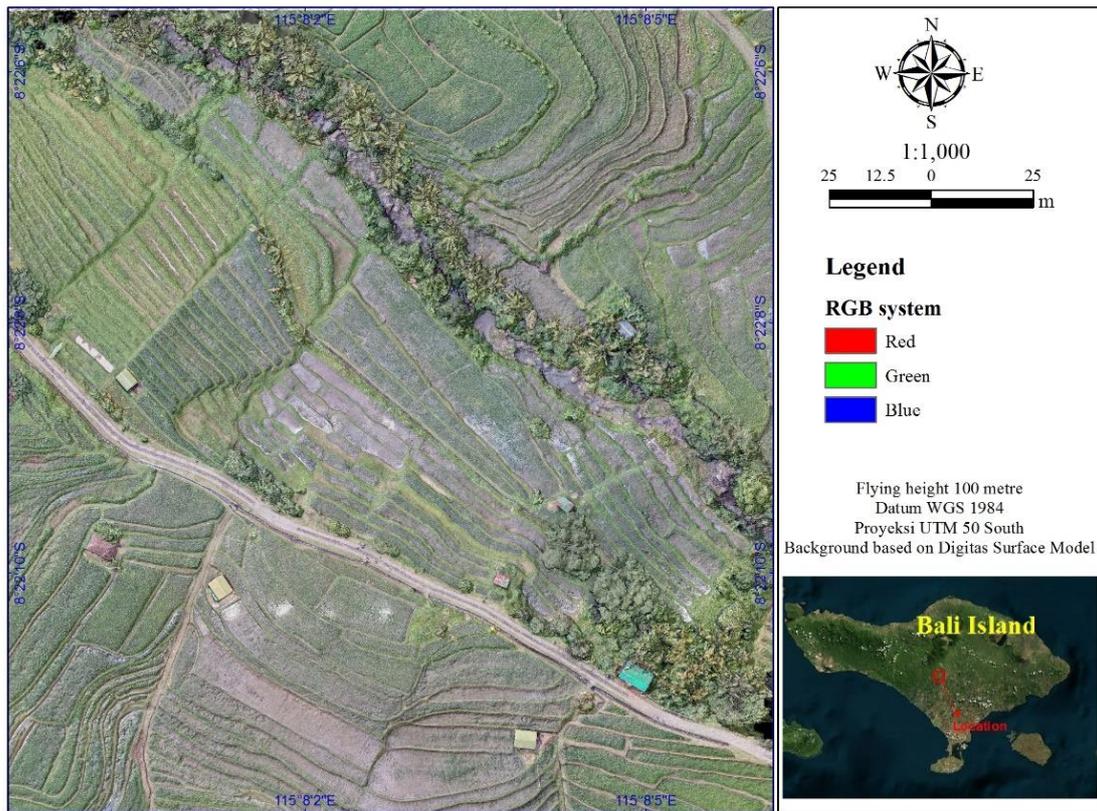


Figure 3. Morphological feature of landscape of Subak Jatiluwi in Bali obtained from Mavic 2 Pro drone at 100-meter height

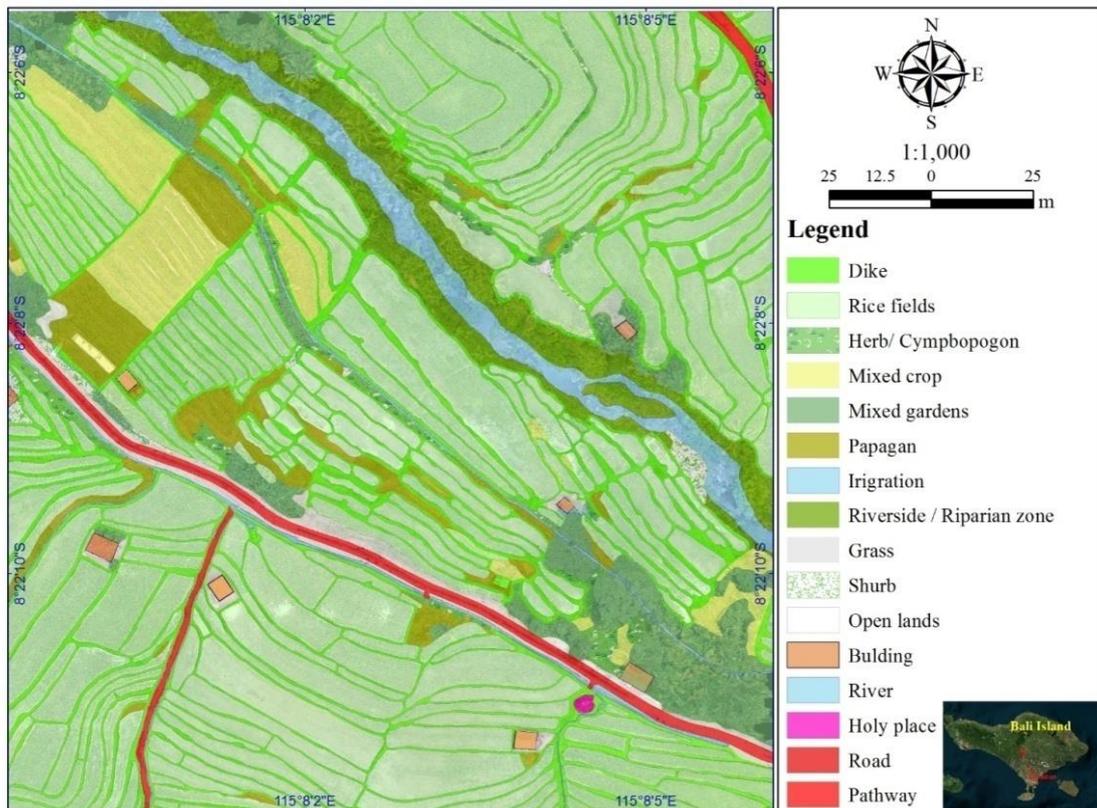


Figure 4. Map of land cover/land use in the sampling site in Subak Jatiluwi, Bali

**Table 3.** The composition of land cover/land use in the sampling site photographed using drone

Land cover type	Area (m <sup>2</sup> )	Percentage
Building	177.45	0.5%
Rice fields	20,389.92	53.8%
Grass	599.3314	1.6%
Herb ( <i>Cymbopogon</i> )	593.44	1.6%
Irrigation	386.78	1.0%
Mixed crop	1,691.32	4.5%
Mixed gardens	2,451.35	6.5%
Open field	84.30	0.2%
<i>Papagan</i>	1,663.02	4.4%
Pathway	204.13	0.5%
Dike/ <i>pematang</i>	5,891.34	15.5%
Holy place	16.96	0.05%
River	1,099.162	2.9%
Riverside/ Riparian zone	1,876.96	5.0%
Road	563.42	1.5%
Shrub	217.68	0.6%

The Jatiluwih rice field complex which has been designed as an ecotourism area also shows the building area that has been made for the needs of both farmers and tourists. However, the appearance of the built-in land is very limited and is more about building concrete roads for tourist access. As a UNESCO world heritage site, the rapid development of tourism is a threat to the sustainability of *subak*, as well as in *subak* Jatiluwih. The results of research by Sriartha et al. (2015) reveal that 87.8% of the sustainability of a *subak* is determined by regional development factors, such as the distance of the *subak* area into the center of tourism, roads, economic facilities, population density, and percentage of non-agriculture family. Apart from paddy fields, other land use classes, both natural land cover and human activity, include riparian zone vegetation, mixed gardens, and mixed agriculture. Several types of plants found in the area include *Cymbopogon citratus*, *Musa paradisiaca*, *Cocos nucifera*, *Syzygium polyanthum*, and other species of woody plants. The vegetation riparian zone consists of ferns, *Arenga pinnata*, other woody plants, and various types of shrubs.

In the sampling site photographed using the drone, the landscape is composed of rice fields (53.8%), dike/*pematang* (15.5%), mixed gardens (6.5%), vegetation riparian zone (5%), and others (Table 3). Roads and pathways are corridors for the mobilities of farmers, while other land uses with small size include area for buildings, such as house and pondok (a place for raising livestock).

The rice farming system in Subak Jatiluwih is semi-organic because the farmers use urea fertilizer at the beginning of planting season. The research results of Salamanca et al. (2015) note that farmers' outlook has changed. They want quick fixes, such as using chemical fertilizers and chemicals to kill pests and weeds. The cropping pattern consists of white rice twice and red rice once a year.

In conclusion, there are a large number of plant species found in Subak Jatiluwih, Bali with some species have high benefit values, especially in term of cultural perspective. This condition strengthens the position of Subak Jatiluwih, not only as a UNESCO's World Heritage site but also as a place with ethnobotanical information which warrants conservation based on culture. The assignment of Subak Jatiluwih as a world cultural heritage will ensure the protection of the diversity of vegetation cover in the area. We recommend that conservation efforts in Subak Jatiluwih should be prioritized on rare plants or plants and those with the highest utilization index value.

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