Land Conservation and The Potential Goal for Food Security in Urban City

by I Ketut Sumantra

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Abstract. Population growth and increasing demand for land for urban development have led to the conversion of agricultural land. Land conversion harms the reduction of agricultural areas and indirectly affects food availability, so efforts are needed to preserve it. The study aims to obtain the availability of paddy fields and the conservation strategies. Evaluation of land use change and availability was analyzed by high-resolution SPOT 6/7 satellite imagery data, slope maps, soil type maps, sub-district administrative boundaries maps, raw rice field maps, spatial pattern planning maps, climate data, and criteria for land suitability for food crops. The strategy of conservation of paddy fields based on the wisdom of *Subak* (Balinese cultural base irrigation system for paddy fields) was analyzed by SWOT. The analysis showed that the converted land areas were 78.5 Ha. The available paddy fields that needed to be conserved were 895.02 Ha, consisting of a moderate suitability class of 556.74 Ha and a very suitable suitability level of 338.28 Ha. The strategy for conservation of paddy fields based on *Subak* wisdom must be implemented through 1) Developing tourist attractions based on *Subak* agricultural activities and rituals, 2) Developing a network of cooperation with the government and business people, 3) Implementing strict *Subak* rules *(awig-awig*), 4) Encouraging *Subak* to be more business-oriented through plant diversification that has market prospects.

1. Introduction

In recent decades, many urban areas have experienced dramatic growth. The high rate of urban population growth has become a global issue that requires comprehensive attention and management because it impacts various aspects of development [1].

Urban agriculture is defined as agricultural activities carried out within the city (intra-urban) and the suburbs (peri-urban) to produce, process, and distribute various food and non-food products by utilizing humans, materials, products, and services in urban areas [2]. Aside from being a food provider [2–4], other benefits of urban agriculture are a green corridor, playing a role in environmental, economic, social, health, and education aspects, and tourists [5,6]. Urban agricultural land use often competes with other sectors such as industry, settlement, trade, and tourism [7]. This competition impacts the emergen of land-use change activities [8]. The land-use change can have a negative impact if not adequately controlled.

Decreasing agricultural land area indirectly affects food availability [3], increasing dependence on food imports, decreasing biodiversity, reducing green open space, and damaging the environment and local culture [9]. To provide such food, it is necessary to preserve sustainable food cropland in urban areas through approaches that can synergize social, cultural, environmental, and economic aspects [10], revise the Urban Spatial Planning to protect the rice fields [11], and increase the contribution of research on land use by various divisions adopted by local wisdom [8]. Population growth and increasing land requirements for development activities have influenced sustainable land use. In Indonesia, the area of paddy fields from year to year continues to decline. In 2018, the land area remained at 7.1 million hectares, but in 2017 it decreased to 7.75 million hectares [12]. Similarly, in Bali Province, the area of rice fields from 2015 to 2017 has decreased by around 2,077 hectares [13].

Denpasar City has an area of 12,778 Ha (2.27% of the total area of Bali Province) consisting of 2,509 Ha of paddy field, 505 Ha of non-paddy agriculture land, and the remaining 9,764 Ha is non-agricultural land, such as roads, settlements, offices, and river [13]. On the other hand, the area of paddy fields in Denpasar-Bali has decreased by an average of about 1.28% per year [13].

Land conversion occurs due to foreign investment entry, labor availability, and population [14]. The impact of the development of shopping centers, settlements, business places such as restaurants, and other infrastructure also triggers land use change [15] in addition to the social and cultural conditions of the local community in land use [16].

The law on the protection of Sustainable Food Agricultural Land and the regulation of the Bali Provincial Spatial Plan has mandated the protection of agricultural land. However, the implementation has not shown encouraging results. Instead, the rate of function of paddy's field was 800 Ha/year during 1998-2018, which exceeded the tolerance limit of 540 Ha/year [11], suggesting that the revision of regional regulations has urgency on protecting agricultural land and Subak as a potential cultural heritage.

Sustainable agriculture aims to balance economic, environmental, and social aspects and create a resilient agricultural system in the long run [17]. This concept has not given equal attention to cultural and spiritual services, let alone integrated into environmental management. Integrating socio-economic, environmental, cultural, and spiritual values is Balinese local wisdom used as a Subak philosophy called Tri Hita Karana [18]. Tri Hita Karana is the concept of a balanced and harmonious relationship of three elements, namely the relationship between humans and God (*parahyangan*), the relationship between humans and humans (*pawongan*), and the relationship between humans and the environment *(palemahan*) [18]. Subak is not just water management but a religious and cultural fortress against globalization and other threats to the local wisdom, including land-use change [19]. Therefore, studying spirituality as the core of the dynamic balance of ecological, economic, and social pillars can significantly contribute to sustainable agricultural development by national cultural identity.

Many studies on the evaluation and determination of sustainable agricultural land have been carried out, as reported by [7,20,21], but the research has not linked the role of society in it. This research, in addition to determining the availability of land, also determines the strategies that must be carried out to preserve rice fields in urban areas with a sustainable *subak* system approach.

Subak plays a vital role in the agricultural system in Bali; for that reason, the Denpasar City Government set a pilot by applying local wisdom through the *Subak Lestari* Program, located in North Denpasar and East Denpasar Districts. The priorities of the Subak Lestari program are protecting and improving farmers' welfare, conservation and promotion of ecosystem services, cultural preservation, and tourism development [22]. The problem is whether, in the era of 4.0, Subak was able to be the guarantor of land sustainability and physical security. This study aims to obtain the existing area of rice fields and evaluate the suitability of land for food crops, as well as its conservation strategy based on local wisdom on Subak sustainability in Denpasar-Bali.

Methods

This study is located in the Subak Lestari area, in North Denpasar and East Denpasar Districts, which extends between 1090 47"- 1100 8' 20" E longitude and 70 32'- 70 28' 54 "S latitude with a total area of about 1,034.82 km2. The research materials and tools include (1) SPOT 6/7 high-resolution satellite imagery with a scale of 1: 25,000, (2) slope maps, (3) soil types maps, (4) sub-district boundaries maps, (5) zoning plan maps, (7) temperature data from 2011-2018, (8) annual rainfall data, and (9) drainage data. The tools in the study include the Global Positioning System (GPS), soil sampling equipment, table of quality/characteristics of irrigated fields, interview guides, voice recorders, and ArcGIS 10.3 software.

To generate the agricultural suitability map, first, the high-resolution satellite data (SPOT 6/7) for the year 2018 was processed using ArcMap for mapping the existing urban agricultural land by using an on-screen digitizing procedure and overlaid by the boundary of agricultural land of the zoning plan map as a shape file. Second, the various potential land characteristic map essential for the growth of various agricultural plants (slope, temperature, soil type, rainfall, and drainage maps) were prepared. The score and weight for each thematic map were calculated based on the provision of FAO [23]. After that, the geographical information system modeling was performed by integrating all thematic maps with their calculated weightage using the weighted overlay analysis method. The agricultural suitability map was finally obtained based on their surface values, and they are further classified into four agricultural suitability levels. Land suitability levels refer to R&D Ministry of Agriculture, 2016 consist of (S1-highly suitable; S2- moderately suitable; S3-marginally suitable; and NS-not suitable). Suitability of land agroclimatic on commodity paddy and corn as in Table 1 and Table 2.

Table 1. Rice plant agro-climatic requirements

No	Requirements Usage / Characteristics Land	Class Suitability Land				Weight
		S1	S2	S3	N	
1	Temperature mean (°C)	24-29	22-24	18-22	<18	5
			29-32	32-35	>35	
2	Rooting media (RC)					
	Drainage	Rather obstructed, moderate	Delayed, fine	Very hampered, a bit fast	Fast	5
	Soil texture	Smooth, a bit fine	Currently	Rather Rough	Rough	5
3	Slope (%)	< 3	3-5	5-8	> 8	5
	Danger erosion	Very low	Low	Currently	Heavy	5

Table 2. Corn crop agro-climatic requirements

No	Requirements Usage / Characteristics Land	Class Suitability Land				Weight
		S1	S2	S3	N	
1	Temperature mean (°C)	20-26	-	16-20	<16	5
			26-30	30-32	>32	
2	Rainfall (mm)	500-1,200	1,200-1,600	>1,600		3
			400-500	300-400	<300	
3	Drainage	Good, a bit hampered	Rather fast, medium	Hampered	Very hampered, hurry	4

No	Requirements Usage / Characteristics Land	Class Suitability Land				Weight
		S1	S2	S3	N	
4	Rooting Media Texture	Smooth, a bit smooth, medium	-	Rather Rough	Rough	4
5	Slope (%)	< 8	8-16	16-30	> 30	4

The SWOT analysis tool was used as a strategic planning approach to formulating strategies for preserving urban agricultural land in Denpasar City, Indonesia. SWOT analysis is a continuation of the situation analysis of internal-external factors, where 'strengths' apply to current forces associated with preserving urban agricultural land, whereas 'opportunities' refers to what actions could be taken to enhance this preservation, and 'weakness' refers to current problems whereas 'threats' are problems waiting to happen. First, face-to-face structured interviews with stakeholders were conducted to conduct the SWOT analysis. A group workshop and personal interviews were held among 42 member participants of pakaseh (Subak leader) as the person who knows the characteristic of the Subak. Second, the open interviews and focus group discussion results were used to find the strengths, weaknesses, opportunities, and threats. Finally, formulate a strategic plan for preserving agricultural land in an urban area based on local wisdom. Figure 1 shows the flowchart of this study.

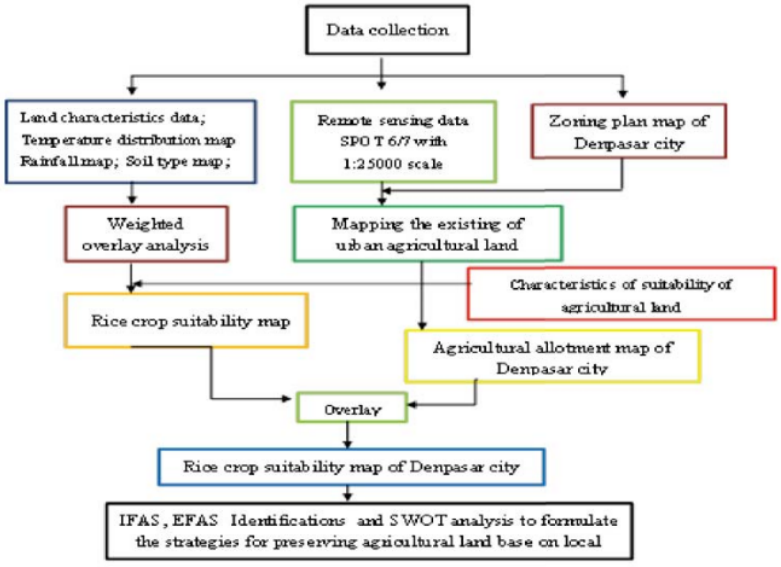

Figure 1. Evaluation flowchart of the suitability of agricultural land

3. Results and Discussion

3.1 Land Suitability for Crops

Based on the zoning plan map of Denpasar City (Figure 2), the North Denpasar and East Denpasar Districts are dominated by residential areas, and some are used as agricultural land. Figure 3 shows the agricultural allotment map in East Denpasar and North Denpasar Districts. Based on the figure, the total area of agricultural land in East Denpasar is 461.51 Ha, and in North, Denpasar is 433.49 Ha.

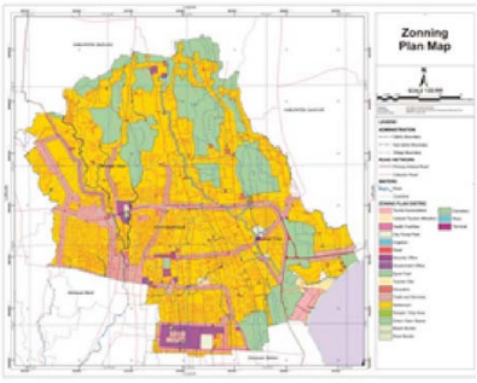

Figure 2. Zoning plan map of North Denpasar and East Denpasar Districts in 2011-2031

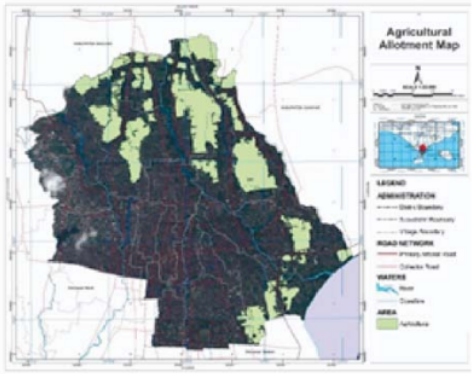

Figure 3. Agricultural allotment map of North Denpasar and East Denpasar Districts in 2019

Figure 2 and Figure 3 show the results of the analysis of the suitability of agricultural land, with the zoning plan map showing a decrease in land area. The area of paddy fields in 2019 was reduced by 78.5 Ha. The most significant land conversion occurred in East Denpasar District, reaching 59.72 Ha, while the rice field conversion in the North Denpasar sub-district reached 18.78 Ha. Agricultural land conversion in the two sub-districts was used for settlements, trade, and services. The remaining crop fields supporting food availability in the two sub-districts are 895.03 Ha (Figure 3). The land available for suitability for rice and corn plants is in categories S1 and S2, as shown in Figure 4 and Figure 5.

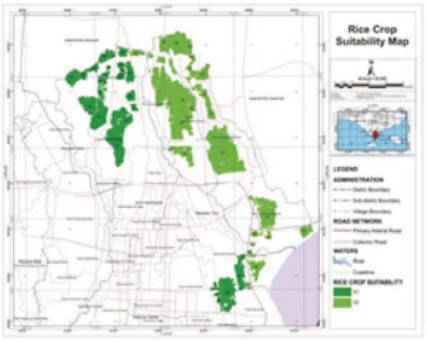

Figure 4. Rice crop suitability map of North Denpasar and East Denpasar Districts

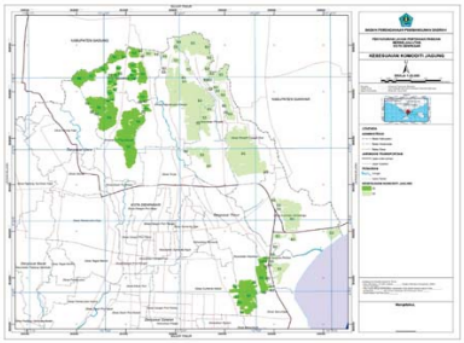

Figure 5. Corn crop suitability map of North Denpasar and East Denpasar Districts

Based on Figure 4 and Figure 5, the area of rice and corn crops with the category of moderately suitable (S2 = 556.74 Ha) is larger than the area of rice crops with the highly suitable (S1=338.28 Ha). The results of agricultural land suitability for each District are shown in Table 3.

Table 3. Rice and Corn crop suitability classes in each village in North Denpasar and East Denpasar

No	Sub-District	Village	Area (Ha)		Total (Ha)
			S1	S2	
1	North Denpasar	Peguyangan Kaja	112.52	7,43	119.94
2	North Denpasar	Peguyangan Kangin	4.11	169.33	173.44
3	North Denpasar	Tonja	-	0.01	0.01
4	North Denpasar	Ubung Kaja	18.45	-	18.45
5	North Denpasar	Peguyangan	121.65	-	121.65
Total Sub-District North Denpasar			256.73	169.34	433.5
6	East Denpasar	Kesiman Kertalangu	-	71.61	71.61
7	East Denpasar	Kesiman Petilan	2.11	21.81	23.92
8	East Denpasar	Penatih Dangin Puri	-	168.38	168.38
9	East Denpasar	Sumerta Kelod	8.76	-	8.76
10	East Denpasar	Kesiman	70.68	0.38	71.06
11	East Denpasar	Penatih	-	117.79	117.79
Total Sub-District East Denpasar			81.55	379.97	461.52
Total			338,28	549,31	895,02

Based on Table 3. in North Denpasar District, the potential for food crops in the very suitable category (S1) is broader than the land in the appropriate category (S2), respectively 256.73 Ha and 176.77 Ha. The most dominant limiting factor in East Denpasar District is the soil permeability because the Regosol soil type dominates the soil.

3.2. Strategy for Sustainable Rice Field Conservation in Urban Areas to Support Food Security

UNESCO has recognized Subak in Bali as a World Cultural Heritage [24]. This recognition reflects several things, including the recognition of a) the existence of Subak institutions, b) the Subak system that applies the Tri Hita Karana (THK) concept, and c) the Subak paddy landscape that contains cultural activities. The importance of the role of Subak in the agricultural system in Bali, the Denpasar City Government, set a pilot by utilizing local wisdom through the *Subak Lestari* Program, with priority programs being the protection and improvement of farmers' welfare, preservation and promotion of ecosystem services, cultural preservation, and tourism development [22]. From 895.02 hectares of rice fields in North Denpasar and East Denpasar, conservation needs to be done with Balinese local wisdom.

A SWOT analysis procedure is needed to formulate a strategy for conserving Subak based on local wisdom. The analysis was performed to maximize the strengths and opportunities while minimizing weaknesses and threats simultaneously. SWOT matrices and proposed strategies for Subak land conservation are presented in Tables 4 and 5, respectively.

Table 4. IFAS Identification of Subak local wisdom in conserving rice fields in Denpasar City

No	Strength	Weight	Rating	Score
1	Subak has a solid philosophical foundation and clear objectives.	0.09	4	0.36
2	The average production that farmers can achieve is between 5-7 tons per hectare of the dry grain harvest	0.06	3	0.18
3	Subak is the only organization farmers, so if empowered will have a robust set (bargaining position) outside the ordinary.	0.06	4	0.24

4	Organizations run by democratic have regulations (awig-awig)	0.07	4	0.28
5	Government support in the form of laws on Subak, policy, and funding	0.07	4	0.28
6	Subak landscape and panorama attractive	0.06	3	0.18
7	Strategic location and close to the provincial capital	0.08	4	0.32
8	Member subak have mutual feelings of respect and mutual belief	0.06	3	0.18
9	All land subak already uses irrigation technical.	0.03	3	0.09
No	**Weaknesses**	**Weight**	**Rating**	**Score**
1	Subak has a dominant social culture compared to business culture,	0.06	3	0.18
2	Moderate rainfall and relatively limited water sources	0.05	3	0.15
3	Production facilities still feel difficult and expensive	0.05	2	0.10
4	Transforming labor from the agricultural sector to non-agriculture	0.05	3	0.15
5	Lack of ability Subak in provide facility	0.05	2	0.10
6	Conversion of paddy fields	0.06	3	0.18
7	Lack of Accessed Street in the Subak area	0.05	2	0.10
8	Lack of administration system and finance,	0.05	2	0.10
	Total internal factors	1.00		3.17

Based on IFAS analysis (Table 4), the total score strength is more significant than the weakness, with an IFAS value of 3.17. Four dominant parameters namely: 1) Has strong philosophy and concrete goals (score 0.36), 2), Strategic location and close to the provincial capital (score 0.32); 3) The organization is run democratically because it has rules (awig-awig), and 4) Government support in the form of laws on Subak, policy, and funding (score 0.28). Whereas dominant factor weakness in preservation paddy field based subak: 1) Subak has a dominant social culture compared to business culture (score 0.18), 2) Transforming labor from the agricultural sector to non-agriculture (score 0.15), 3) Moderate rainfall and relatively limited water sources (score 0.15), and 4)) Conversion of paddy's field (score 0.18).

Table 5. EFAS Identification of Subak local wisdom in conserving rice fields in Denpasar City

No	**Opportunities**	**Weight**	**Rating**	**Score**
1	Market opportunities for agriculture product	0.08	3	0.24
2	Diversification opportunities for plants that have high selling points	0.08	4	0.32
3	Availability of business loans from the government	0.06	3	0.18
4	Supporting from the government because in line with the vision development tourist culture	0.08	4	0.32
5	There is funding from the government for Subak conservation.	0.10	3	0.30
6	Strategic location and close to the provincial capital	0.08	3	0.24
7	Subak opportunity as a tourist attraction	0.09	4	0.36
8	Synergy Among agriculture, animal husbandry, and fisheries must be encouraged to realize CLS (Crop, Life Stock System).	0.07	3	0.21
No	**Threats**	**Weight**	**Rating**	**Score**
1	Shifting the conditions of socio-agrarian society towards industrial society caused a decrease in interest in work in agriculture,	0.06	3	0.18

2	Taxes for agricultural land are still high, so they need to be subsidized	0.05	2	0.10
3	Population growth and conversion of paddy fields.	0.06	3	0.18
4	The growth of private entrepreneurs engaged in agribusiness and managed professionally can be a competitor of the Subak community	0.07	3	0.21
5	More many worker effort farmers were taken by power work outside subak	0.06	2	0.12
6	Constraint pests and diseases	0.05	1	0.05
	Total external factors	1.00		3.01

Analysis EFAS (Table 5) shows that the opportunity factor value is more significant than the threat factor value, with a total EFAS score of 3.01. Four factors dominant as opportunity subak local wisdom in conserve paddy fields, namely 1) Subak opportunity as a tourist attraction (score 0.36), 2) Diversification opportunities for plants that have high selling points (Score 0.32), 3) There is funding from the government for Subak conservation (score 0.30), 3) Strategic location and market opportunities score 0.24). Whereas the most dominant threat faced are 1) The growth of private entrepreneurs engaged in agribusiness and managed professionally can be a competitor of the Subak community (score 0.21), 2). Shifting the conditions of socio-agrarian society towards industrial society, causing a decrease in interest in work in agriculture, 3) Population growth and conversion of paddy fields, and 4) More farm workers are taken from outsiders.

The SWOT analysis results indicate that eight strategies can be carried out in preserving paddy's field based on the local wisdom of *Subak* (Table 6). The eight strategies are 1). Increase the value of ritual and spirituality. 2). Collaborating with the government in funding, fostering, and developing Subak as a tourist attraction. 3). Encourage Subak to be more business-oriented through diversification of plants that are adaptive to the environment and have market prospects. 4). Create business units, and 5). Strengthening and implementing Subak rules both for supporting businesses and protecting paddy fields. 6). Empower the Subak members in plant and unique business management. 7. Establishing the Subak economic business institutions. 8) Selective and rigorous in developing facilities to reduce land-use change.

Table 6. SWOT matrix and alternative strategies in preservation paddy field

Internal Factor / **External Factor**	**Strength (S)**		**Weakness (W)**	
	Factor	Score	Factor	Score
	Subak has a solid philosophical foundation and clear objectives	0.36	Subak has a dominant social culture compared to the business culture	0.18
	The organization is run democratically because it has rules (*awig-awig)*	0.28	Transforming labor from the agricultural sector to non-agriculture	0.15
	Government support in the form of laws on Subak, policy, and funding	0.28	Moderate rainfall and relatively limited water sources	0.15
	Strategic location and close to the provincial capital	0.32	Conversion of paddy fields	0.18
Opportunity (O)				
Factor	**Score**	**SO Strategy**	**WO Strategy**	
Diversification opportunities for plants that have high selling points	0.32	1. Increase the value of ritual and spirituality by the Subak's foundations and goals and apply the *Subak awig-awig* rules both	3. Encourage Subak to be more business-oriented through diversification of plants that are adaptive to the environment and	
Support from the government for developing cultural tourism	0.32			

There is funding from the government for Subak conservation	0.30	for soil protection and business development diversification of potential market-integrated plants with the tourism sector (S1, S2, S3, O1, O2, and O4) 2. Collaborating with the government in funding, fostering, and developing Subak as a tourist attraction. (S1, S2, S4, O2, O3, O4)	have market prospects and create tourist attractions so that agriculture can prevent labor transformation and suppress the conversion of agricultural land (W1, W2, W3, O1, O2, O4) 4. Subak community, together with the government, creates business units, reinforces the rules for both protecting land and business units owned, and opens new business fields (W3, W4, O2, O4)
Subak opportunity as a tourist attraction	0.36		
Threat (T)			
Factor	**Score**	**ST strategy**	**WT Strategy**
Shifting the conditions of socio-agrarian society towards industrial society caused a decrease in interest in work in agriculture.	0.18	5. Strengthening and implementing Subak rules both for supporting businesses and protecting paddy fields (S1, S3, T1, T2) 6. Empowering the Subak members both in the field of plant management and unique business management based on the potential of Subak local wisdom to minimize business competition and labor competition from outside (S2, S4, T3, T4)	7. Collaborate with the government in strengthening the Subak institutions by establishing the Subak economic business institutions (W1, W2, T1, T3). 8. Selective and rigorous in developing facilities to reduce land-use change (W2, W4, T2, T3)
Population growth and conversion of paddy fields	0.15		
The growth of private entrepreneurs engaged in agribusiness and managed professionally can be a competitor of the Subak community	0.21		
More farmworkers are taken from outsiders	0.12		

Increasing the values of ritual and spirituality according to the *Tri Hita Karana* philosophy and applying the *Subak* rules (*awig-awig*) are necessary for protecting the paddy field [21] and developing business units of *Suba*k based on plant diversification. Preservation of paddy fields is the essence of the relationship between ritual, spirituality, and sustainable development. Sustainable development with three main pillars (ecology, economy, and social) recognizes the existence of ecosystem services in environmental management [25]. Still, cultural and spiritual services do not seem to have received equal attention. Subak is not only water management but is a stronghold of religion and culture against globalization and various other threats to local wisdom [19]. Therefore, the study of aspects of spirituality as the core of the dynamic balance of the ecological, *Subak* activities, *Subak* philosophy, and *Subak* rituals can be used as tourist attractions [11]. In addition, *Subak*, which has beautiful natural scenery and fresh air conditions, can be developed as an agro-ecotourism area [25,26]. To preserve and enhance the bargaining position and protection of agricultural land, *Subak* must assume a more strategic role and function. The technology that needs to be offered to the local farmers is appropriate technology that is relevant to meet the reality of needs and becomes a solution to the community's real problems. Agricultural intensification is essential to ensure food security and slow the expansion of agricultural and cultural land. If the reality of the problem is the low productivity of crops, then the appropriate technology to increase production needs to be developed. If the problem is limited agricultural land, farmers can focus on producing high-value food products through crop diversification and health products through the application of organic agriculture [27,28]. If the real problem for farmers is finding a market for the raw crops, the technology that needs to be developed is processing and packaging technology and designing applications to help local farmers find markets for raw crops. Not all of the various processing, distribution, and marketing technologies can be done by farmers themselves. Still, it would be perfect if done together in the form of agricultural economic business institutions formed by Subak.

4. Conclusion

Availability of raw rice fields in North Denpasar and East Denpasar is 895.02 Ha, with a moderately suitable level (S2) broader than land with a very suitable level (S1) with an area of 556.74 Ha (S2) and 338.28 Ha (S1), respectively. The concept of preservation must be implemented because of several opportunities and strengths that can be developed as a land conservation strategy: 1) The development of tourist attractions is based on agricultural activities and rituals. 2) Developing a network of cooperation with the government and entrepreneurs. 3) Implementation of customary rules that are strict for controlling land-use change. 4) Encouraging the traditional conservation to be more business-oriented through diversification of plants that are adaptive to the environment and have market prospects. More personal views might reflect the investigated phenomena' factual descriptions to avoid subjective findings. Further study is recommended in a broader area of Bali to generate generalizability of findings.

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