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MULTIFUNCTIONALITY OF PADDY FIELDS AND THREATS TO THE SUSTAINABILITY OF TRADITIONAL SOCIO-ECOLOGICAL SYSTEMS IN BALI

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ABSTRACT – The Subak system in Bali faces an existential threat due to agricultural modernisation and massive land conversion triggered by mass tourism. Using a descriptive qualitative approach through in-depth critical reviews and field interviews in the UNESCO World Cultural Heritage Landscape, this study aims to analyze the multifunctional spectrum of paddy fields; evaluate farmers' perceptions to the dual roles of subak system; assess an adaptive model of agribusiness cooperative integration into subak system; and develop Multiaspect Sustainability Analysis (MSA) frameworks for assessing the sustainability of rice farming systems. The results of the analysis show that the traditional paddy fields play a broad range of multifunctional roles, but its existence is seriously threatened by the pressure of other sector and economic inequality. The farmers' perceptions are relatively good (80.48%), with a high level of knowledge (74.86%) and a strongly agree attitude (86.09%) towards institutional strengthening. As an adaptive solution, the Cooperative of Jatiluwih Kertha Agroecotourism was successfully integrated to manage a modern supply chain without destroying the area's authentic value. This research provides a scientific contribution in the form of an operational blueprint and holistic policy recommendations to ensure the sustainability of traditional socio-ecological systems from the marginalization of the global tourism industry.

Keywords: agribusiness cooperative; paddy fields multifunctionality; socio-ecological system; subak irrigation system; sustainable tourism destination

1. INTRODUCTION

The traditional irrigated rice ecosystem in Monsoon Asia is a large-scale artificial wetland that is not only crucial for global food security but is also internationally recognised for its multifunctionality in agriculture that goes beyond primary production (Budiasa, 2016b). Rice fields provide essential ecosystem services, including hydrological functions such as flood mitigation, groundwater recharge, water purification, erosion prevention, climate change mitigation, biodiversity, and secondary functions related to rural amenities for recreation and visual aesthetics (Budiasa, 2016b; Nakagami et al., 2016). In Indonesia, the conceptual and operational manifestation of the public functions intensively is realized in the Subak system in Bali Province - a traditional socio-religious-agrarian-economic institution based on local wisdom that manages the distribution of irrigation water, whose universal significance has been recognized worldwide through the designation of the Cultural Landscape of Bali Province as a World Culture Heritage Sites by UNESCO in 2012 and the submission of the Subak Bugbug, Subak Uma Pahang, Subak Gelogor, Subak Lumpadang, and Subak Tegakin area within the Bugbug Traditional Village, Karangasem Regency as a GIAHS (Globally Important Agricultural Heritage Systems) site by FAO (Budiasa, 2016b; ICOMOS & ICCROM, 2015). However, the traditional socio-ecological system is now facing a massive existential threat due to the penetration of agricultural modernization which triggers environmental degradation through the use of excessive synthetic chemical inputs (Gubernur Bali, 2019), as well as the rampant expansion of the international tourism industry which encourages uncontrolled conversion of rice fields, fragmentation of irrigation networks, and commodification of spiritual values inherent in the cultural landscape (ICOMOS & ICCROM, 2015).

Global and regional literature reviews consistently confirm the ecological capacity of rice fields to stabilise downstream river flows and maintain soil fertility, in addition to their very real environmental and economic contribution to the rural ecotourism sector (Budiasa, 2016b; Nakagami et al., 2016). Environmental economics studies previously implemented the Contingent Valuation Method (CVM) in Subak Jatiluwih, which proves that the non-market economic value of rice fields for recreation and cultural heritage has a very high Willingness to Pay (WTP) value from local, domestic and foreign tourists, whose value often exceeds the financial benefits from pure rice production (Budiasa, 2016a). Institutionally, in-depth study by Lansing and de Vet (2012) places the network of water temples in Bali as a complex adaptive system that is very sophisticated in regulating collective planting schedules for natural pest control, which is legally strengthened by the regional government through Regional Regulation of Bali Province Number 9 of 2012 concerning Subak which protects traditional Pekaseh rights (Gubernur Bali, 2012), as well as Regional Regulation of Bali Province Number 8 of 2019 concerning Organic Agricultural System to Bali's agroecosystem health restoration due to the long term impact of green revolution (Gubernur Bali, 2019).

Although subak systems have received regulatory recognition and formal protection globally, the integrity of traditional socio-agroecological systems is in critical condition due to the paradox of tourism and the dissonance in policy implementation at the site level. Traditional Balinese farmers are trapped in structural economic inequality: the landscape of terraced rice fields that they maintain with operational costs, customary inheritance and independent labor through a large sawinih system has become the main aesthetic commodity of global tourism (Gubernur Bali, 2012); However, the greatest economic profits are enjoyed by capitalists who provide tourism accommodation services, while the burden of high land taxes and damage to irrigation infrastructure due to commercial development remains disproportionately borne by farmers (Budiasa et al., 2019). This condition is exacerbated by the Advisory Mission report from ICOMOS and ICCROM (2015) which highlights the weak structural coordination between formal government law and customary law (*awig-awig*) of subak in stemming land conversion in the buffer zone, which systemically threatens the availability of irrigation water, degrades the Outstanding Universal Value of the UNESCO world heritage, and triggers the extinction of the communal water management system that has survived for thousands of years.

Based on literature mapping, a fundamental theoretical and practical research gap was identified, where previous studies tended to be separated into two extreme poles: anthropological-cultural studies that focused on the *Tri Hita Karana* (THK) philosophy without touching on the pragmatism of farmers' financial sustainability (Lansing & de Vet, 2012), or pure environmental economic studies such as CVM valuations that only measure hypothetical WTP value estimates without offering operational instruments to redistribute non-market income to the farming community fairly (Budiasa, 2016a). There is no socio-ecological system integration model capable of bridging traditional-communal irrigation water management with community-based economic institutional engineering, institutionalised directly within the subak organization, to prevent land conversion.

This study contributes to existing scholarship by examining how multifunctional agricultural landscapes can be sustained through institutional adaptation. Specifically, it explores how cooperative-based economic activities can be integrated within the traditional governance structure of the subak system to strengthen farmer livelihoods while maintaining ecological and cultural functions.

To answer the problems and fill the research gaps that have been described, this research is directed at four strategic objectives: (1) comprehensively analyzing the multifunctional spectrum of the traditional subak paddy fields in Bali and measuring the magnitude of the socio-ecological threats faced due to mass tourism and land conversion; (2) evaluating the perceptions, level of knowledge and attitudes of local farmers (subak members) in the face of tourism expansion and socio-economic change; (3) assessing an adaptive model of integration and internalisation of agribusiness cooperative into the traditional organisational structure and customary rules (*awig-awig*) of subak through a participatory approach; and (4) develop a comprehensively multiaspect sustainability analysis to ensure the long-term sustainability of subak's traditional socio-ecological system as a UNESCO World Cultural Heritage site. This study adopts a socio-ecological systems perspective, which views sustainability as dependent upon interactions among ecological resources, local communities, and governing institutions.

2. MATERIAL AND METHODS

The study site was within the World Cultural Heritage Landscape sites of Bali Province. The sites include Lake Batur (A1) and Supreme Water Temple Pura Ulun Danu Batur (A2); Subak Landscape of Pakerisan Watershed (B); Subak Landscape of

Catur Angga Batukaru (C); and Royal Water Temple Pura Taman Ayun (D), illustrated in Figure 1. This study was focused on Subak Jatiluwih within sites B and C.

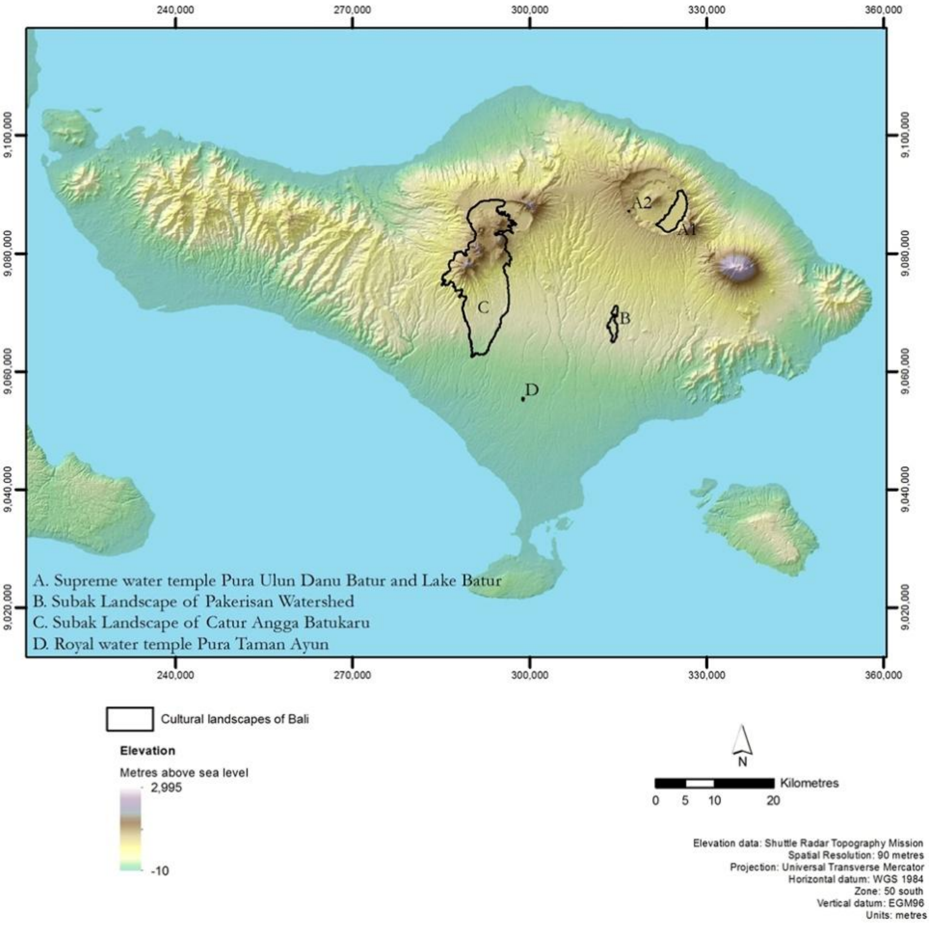

Figure 1. Index map of the cultural landscapes of Bali (Ministry of Culture and Tourism & Government of Bali Province, 2011)

This study applied an in-depth critical review to the relevant research results documented in a final report and/or published in a printed or electronic book, book chapter, or scientific journal. This study was carried out from February 4, 2026, to May 31, 2026. An in-depth discussion with the Head of the Mandhara Research Institute (MRI) Foundation, the Head of the Communication Forum of Pekaseh Agung of Pakerisan Watershed, and the Head of the Communication Forum of Pakerisan Watershed was held on May 26, 2026 at the SDGs Centre, Udayana University, Denpasar, Bali. Field visit for an in-depth interview with the representative member of Subak Jatiluwih, the Head of Subak Jatiluwih, and the Head of the Customary Village of Gunungsari in Jatiluwih Village, conducted on May 30, 2026.

Secondary data were collected from an in-depth critical review of relevant references, and primary data were gathered through in-depth discussions and interviews, which were then descriptively analyzed.

3. RESULTS AND DISCUSSION

3.1 Multifunctionality of the Traditional Subak Paddy Fields in Bali

Subak is a traditional organisation for water and/or crop management at the farm level in Balinese customary society with socio-agrarian, religious and economic characteristics that have historically and continuously grown and developed (Gubernur Bali, 2012). The subak system has been established for more than a thousand years. Based on the THK philosophy, it consists of three main elements, namely: (a) *Parhyangan,* the religious element of the society assumes material expression in the temples that are built everywhere for honoring God, and the ritual ceremonies, that are performed daily; (b) *Pawongan*, farmers as members of the subak, are the social element of the society; and (c) *Palemahan*, the environment element of the society includes the paddy fields, the source of the irrigation water and all the other places used by the subak members for implementing the activities related to the farm operation and the religious ceremonies. Daily life in the subak societies is based on the THK (three happiness causes) philosophy, with the three harmonious relationships among: (a) the human beings and God, as the creator of the world; (b) the human beings and the environment; and (c) the human beings themselves. The general and detailed rules for its implementation are included in the subak rules called as *awig-awig* and *pararem* (bylaws) (Public Works Office of Bali Province, 1997). The subak system, as a manifestation of the THK philosophy, was inscribed on the UNESCO World Heritage list on July 6th, 2012 (Kementerian Pendidikan dan Kebudayaan Republik Indonesia, 2013).

The concept of multi-functionality in agriculture, first introduced by the OECD in 1992, establishes that paddy fields extend far beyond simple food production to serve as vital artificial wetlands with diverse ecological and socio-economic benefits. Ecologically, paddy fields function as critical infrastructure for environmental management, providing flood mitigation and control, groundwater recharge, sediment and soil erosion control, water purification, and landslide prevention. Furthermore, they contribute significantly to biodiversity conservation, downstream river flow stabilisation, air purification, and climate regulation and mitigation. Beyond these environmental services, the multifunctional framework recognizes the profound impact of paddy fields on regional economic vitality, rural livelihoods, and food security, while simultaneously serving as platforms for recreational activities, rural amenities, and the preservation of cultural heritage, aesthetic values, and community identity (Adnyana & Setyanto, 2010; Groenfeldt, 2006; Huang et al., 2006; INWEPF, 2006; Kim et al., 2006; Yamaoka, 2009; Zakaria & Abdullah, 2015)

The Japanese Institute of Irrigation and Drainage (JIID) then summarize it is said to have the following functions: (1) Preservation of land (by storing rain water and other means, to prevent flood and landslides); (2) Protection of watershed areas (by permeation of water through paddies and fields, to recharge underground water); (3) Ease severeness of climate (by existence of water paddies, especially in summertime, to ease the severeness of climate of surrounding area); (4) Preservation of natural environment (to preserve environment to allow the existence of water birds, fireflies, dragonflies and small fishes); (5) Forming a good landscape (to provide beautiful scenery of countryside); (6) Inheritance of culture (to inherit old traditional culture and event such as festivals); (7) Recreation and relaxation (by offering place of relaxation and recreation); (8) Mental education (by experiencing nature and agriculture, to cultivate aesthetic sentiment to understand preciousness of life); and (9) Maintenance and revitalization of local society by job security in villages, to retain the population of villages (Budiasa, 2016a; Budiasa, 2016b).

The Subak Jatiluwih area is 303 hectares, of which 227.41 hectares are effective paddy fields. The annual cropping pattern implemented in the paddy field is Merah Cendana (IDN-01-05020-12658) (Balai Besar Penelitian dan Pengembangan Bioteknologi dan Sumberdaya Genetik Pertanian, 2008), which is planted every January. The second crop is a High Yield Variety (HYV) of white rice, which is usually transplanted in July or August. Based on an in-depth interview with a local farmer (Mr. I Wayan Semarajaya) on May 30, 2026, the paddy field productivity was around 5.5 tons of Harvested Dry Paddy (HDP) with straw per hectare for the Merah Cendana variety, while around 6.0 tons of HDP per hectare for the HYV white rice variety. The market prices of Merah Cendana and HYV white rice are IDR10,000 per kg and IDR6,500 per kg, respectively. So, the financial direct benefit from rice farming was around IDR21,376,540,000 annually.

Figure 2. Tourism activity within Subak Jatiluwih

Besides their main function of producing food, the terraced paddy fields within Subak Jatiluwih offer lovely scenery and also serve other functions, providing a place for recreation and relaxation, especially for outsiders (Figure 2). In 2014 as the first year of tourist records, there were 17,570 domestic tourists and 147,574 foreign tourists visited Jatiluwih. The car parking fee was IDR5,000 per unit, and the entrance ticket charges were IDR20,000 and IDR10,000 for foreign and domestic tourists, respectively, including an insurance premium of IDR500 per ticket. The total revenue collected from visitors to Jatiluwih in 2014 was IDR3.2 billion. About 25% of total tourism revenue, after insurance premium payment, was distributed to operational costs for tourism management in Jatiluwih, operated by the Jatiluwih Village Tourism Management Board. As shown in Table 1, only 6.63% (IDR 206,586,108.38) of the total revenue after insurance payments was received by the Subak Jatiluwih in 2014.

Table 1 Jatiluwih tourism revenue distribution

No	Proportion	Amount (IDR)	Remarked
R1	100% (level 1)	3,200,000,000.00	Initial revenue
R2	Insurance	82,572,000.00	IDR500/visitor
R3	100% (level 2 = R1-R2)	3,117,428,000.00	Total revenue after insurance
R4	25%	779,357,000.00	Operational of Jatiluwih Tourism
R5	7.5% [=10%*(R3-R4)]	233,807,100.00	Incentive for Jatiluwih Tourism Management Board
R6	10.125% [=15%*(R3-R4-R5)]	315,639,585.00	Development and Promotion
R7	25.819% [=45%*(R3-R4-R5-R6)]	804,880,941.75	Tabanan Regency
R8	31.556% [=55%*(R3-R4-R5-R6)]	983,743,373.25	Jatiluwih Village
R9	9.467% (=30%*R8)	295,123,011.98	Customary Village Jatiluwih
R10	6.311% (=20%*R8)	196,748,674.65	Customary Village Gunungsari
R11	7.889% (=25%*R8)	245,935,843.31	Administrative Village Jatiluwih
R12	6.627% (=21%*R8)	206,586,108.38	Subak Jatiluwih
R13	1.262% (=4%*R8)	39,349,734.93	Subak Abian Jatiluwih

Source: Budiasa, 2016b

The distribution of tourism revenue reveals a significant disconnect between value creation and value capture within the heritage landscape. While the terraced rice fields maintained by subak members constitute the primary attraction for visitors, only a small proportion of tourism revenue is returned directly to the institution responsible for maintaining the landscape. Consequently, the economic benefits derived from tourism remain weakly aligned with the conservation responsibilities borne by farming communities.

3.2 Local Farmers' Perception of the Dual Roles of the Subak System

Ustriyana et al (2018), based on their study on "Development of Tourism Business Synergy Model with Subak-based Farming for Empowerment and Sustainability of Subak Institution in Bali" found that the local farmer provided "good perception" to the dual roles of the subak system, firstly for managing a traditional subak irrigation system and secondly for managing a professional agribusiness.

Based on the perception analysis presented in Table 2, the degree of farmers' knowledge, as one of the constituents of farmers' perceptions of the subak system reinforcement, was 74.86 per cent. Furthermore, the farmer's attitude to the subak system reinforcement was in the strongly agree category with a score of 86.09 per cent. Based on both knowledge and attitude indicators, the farmer's perception was 80.48 per cent (in the good category). These findings indicate that farmers are generally supportive of institutional strengthening initiatives. The positive perception towards the dual role of the subak suggests a willingness among members to adapt traditional institutions to changing economic conditions while maintaining their core irrigation, social, and cultural functions.

Table 2: Percentage of perception score achievement based on the maximum score of knowledge and attitude indicators

Variable	Operational Variable	Number of respondents for each category					Total	Mean of Score	
								Score	Category
Perception	Knowledge	VH	H	M	L	VL			
		7	45	17	1	0	70	74.86%	High
	Attitude	SA	A	NC	NA	SNA			
		36	34	0	0	0	70	86.09%	Strongly Agree
Total								80.48%	Good

Source: Ustriyana et al., 2020

Notes: VH=very high, H=high, M=moderate, L=low, VL=very low
SA=strongly agree, A=agree, NC=no comment, NA=Not agree, SNA=strongly not agree

3.3 Adaptive Model of Integrating Agricultural Cooperative into a Traditional Socio Ecological System

The best practice in implementing the dual role of the subak system, previously established at Subak Guama. It is located in Tabanan Regency, Bali Province, with a total paddy field area of approximately 172 hectares and is collectively managed by 544 subak members. It was successful to play dual roles: traditional irrigation management and professional agribusiness management. The dual role of the subak system began in 2002 with financial support from the Central Government of Indonesia to the Integrated Agribusiness Group under the subak system, amounting to IDR843,200,000. The financial support was allocated for operating the three main business units: (1) Crop Livestock System (CLS) - IDR663,500,000; (2) Integrated Crop Management (ICM) - IDR98,000,000; and (3) Credit program - IDR81,700,000. Some non-governmental programs, such as rice seed breeding, organic fertiliser production, cattle feeding, rice milling unit (RMU) service, hand tractor and power thresher rental service, were locally initiated and operated by the business group. In 2003, Integrated Agribusiness Cooperative was legally established as part of the agribusiness group, which was clearly an integral part of the Subak Guama organisational structure (Yadnya, 2007). In 2017, the cooperative's financial assets reached IDR6,000,000,000. The net profit generated by professional agribusiness management was not only allocated to increase business investment but also distributed to each member and used to finance the daily activities of the subak system.

In adoption of the successful dual role of Subak Guama, Budiasa et al. (2019) have initiated "Developing agricultural cooperative model for supporting subak-based agribusiness development within the UNESCO World Culture Heritage Site, Bali, Indonesia," which is financially supported by the Seed Fund for Research and Training (SFRT) Program of SEARCA. The project site was in Subak Jatiluwih, Tabanan Regency, with terraced paddy fields of 303 hectares, collectively managed by 545 subak members. The beautiful terraced paddy fields and subak members are distributed into seven sub-subak, called as *Tempek:* Telabah Gede, Besi Kalung, Kedamean, Uma Duwi, Kesambi, Gunung Sari, and Uma Kayu.

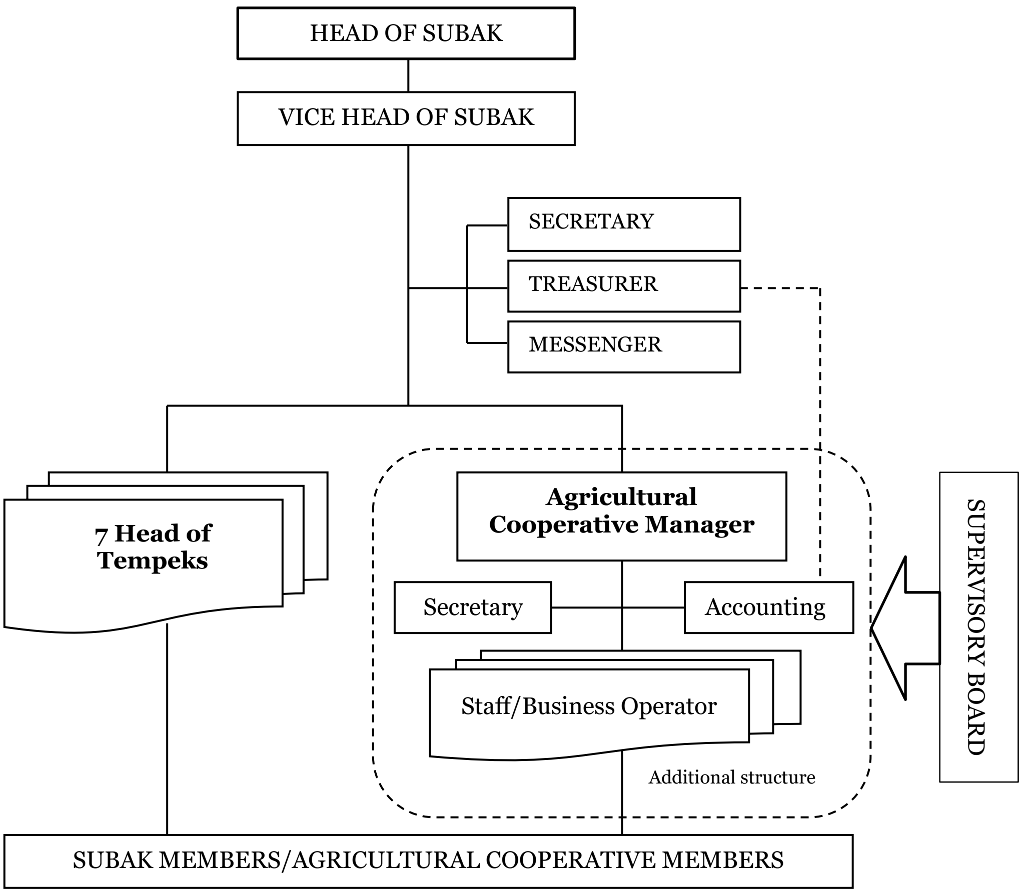

Figure 3. Organizational structure for internalizing agricultural cooperative into subak system (Budiasa et al., 2019)

The first stage of the project was Participatory Rural Appraisal 1 (PRA-1) that integrating the potential business units into the subak organization structure (Figure 3) and internalization of business article into article 35 of *awig-awig* of the subak (Tabel 3). The second stage, PRA-2, involves conducting an in-depth discussion on business unit planning, cooperative organization structuring, and job descriptions. And the third stage was PRA-3 – legal establishing the agricultural cooperative as an integral part of Subak Jatiluwih institution. A Cooperative of Kertha Agroekowisata Jatiluwih was legally established on July 16th, 2019, under the Ministry of Cooperative and Small and Medium Enterprises Number 014049/BH/M.KUKM.2/VII/2019 concerning Ratification of the Kertha Agroekowisata Jatiluwih Cooperative's Deed. It is located in Banjar Gunungsari, Jatiluwih Village, Penebel District, Tabanan Regency, based on Notarial Deed No. 45 on July 6th, 2019, by Public Notary Purnomo Santoso in Tabanan Regency.

Table 3. Components of the structure of the *awig-awig* of Subak Jatiluwih

Article	Area regulation
1	Name, area border, area, and name of 7 sub-subaks, called as Tempek (Telabah Gede, Besi Kalung, Kedamean, Uma Duwi, Kesambi, Gunung Sari, Uma Kayu)
2	Operational base
3	Subak purposes
4-7	Subak member
8-11	Subak administrators (management)
12-13	Subak meetings (subak member meeting and subak management meeting)
14	Wooden bell (called a *Kulkul*)
15	Asset of Subak Jatiluwih
16	Danger/disaster
17-21	Temple, religious leader, and traditional ceremonial of subak
22-23	Paddy field and housing
24-26	Water resource and water allocation
27-28	Cropping pattern
29	Crop pests and diseases control
30	Herding ducks and fishing
31-32	Decision
33-34	Punishment
35	**Change to the *awig-awig***
36-38	Closing articles

Source: Budiasa et al., 2019

The cooperative offers some services such as: (1) Producing, processing, and marketing the local red rice and other agro-touristic goods; (2) Retail Market Unit by using cashier software for selling agricultural inputs (seeds, fertilizers, and pesticides) and agro-touristic goods or souvenir; (3) Microfinance Service Unit by using microfinance software for providing such as micro-credit and saving services for the cooperative members; (4) Rental Business Unit for tourism facilities such as mountain bike for tourists/visitors and agricultural equipment such as hand tractor and power thresher; and (5) Organic fertilizer production.

Importantly, these economic activities are carried out through existing subak institutions and customary rules rather than through parallel external organizations. This arrangement enables economic adaptation while preserving the social and cultural foundations of the traditional irrigation system.

3.4 Multiaspect Sustainability Analysis (MSA) Frameworks

The sustainability challenges facing Subak Jatiluwih extend beyond agricultural production alone. Environmental pressures, tourism development, institutional adaptation, labour availability, and infrastructure changes interact to influence the long-term viability of the socio-ecological system. Assessing sustainability therefore requires a framework capable of integrating these multiple dimensions.

The pressure from the tourism sector on the agriculture in Subak Jatiluwih is phenomenal. The intensive intrusion of tourist activities has damaged many paddy fields in Jatiluwih, and farmers have never received fair, direct compensation. Farmers indirectly benefited from subak revenues totalling IDR 206,586,108.38 in 2014 (Table 1), which were collectively used to finance subak activities, especially ritual activities at Subak Temple. In this case, farmers are no longer required to share the costs of financing these ritual activities. However, some farmers feel very disadvantaged because they have to spend their own funds to repair every bund in their paddy fields that has been damaged by tourist traffic.

Several areas of paddy fields in Jatiluwih appear to have been converted to the construction of accommodation, restaurants, cafés and other buildings. Likewise, some catchment areas have also been converted into accommodation and tourism support buildings. It is feared that this will threaten the hydrological cycle balance in the Jatiluwih area, thereby affecting the natural water supply and the sustainability of rice farming in Subak Jatiluwih.

Based on an in-depth interview, planting Merah Cendana rice every year requires unique traditional technology for both seeding and harvesting. Currently, the availability of workers to manually harvest Merah Cendana rice using "ani-ani" is increasingly scarce, so some harvest workers have to be brought in from neighbouring villages with experience harvesting similar rice. The youth's lack of interest in continuing agricultural activities in Subak Jatiluwih further threatens its sustainability. It is urgent to introduce technological innovations that capture the youth's interest, and to control the sale of land to outside parties and the conversion of rice fields to non-agricultural uses.

A comprehensive framework presented in Table 4 has been derived from the International Sustainable Agriculture Standards (Rainforest Alliance, 2020). These standards are grouped into five aspects, and each aspect contains several sustainability factors. By using these frameworks which are supported by a powerful of Exsimpro software (https://msa.exsimpro.com/license-msa: MSA-220911-AP), the multiaspect sustainability status of rice farming system within Subak Jatiluwih can be determined comprehensively. The scenario analyses available in the software will be very helpful and useful in formulating scenarios for improving or optimizing the sustainability performance.

Table 4. MSA framework for assessing sustainable agricultural systems

ASPECT	FACTOR
Environment	1. Biodiversity and Wildlife Protection 2. Soil conservation and soil fertility management 3. Water resource and riparian zone management 4. Waste, wastewater, and pollution management 5. Integrated pest management and agrochemical reduction 6. Energy efficiency and GHG emission reduction 7. Climate change adaptation and agroforestry development
Socio-Economic	8. Decent wage and income 9. Agricultural productivity and farm profitability 10. Household income diversification 11. Access to financial services and sustainability investment 12. Occupational health, safety, and working conditions 13. Capacity building, training, and agricultural extension services 14. Efficiency of agricultural input utilization 15. Household economic resilience
Legal and Institution	16. Compliance with sustainability regulations and standards 17. Institutional and management capacity of farmer organisations 18. Risk assessment and management plan implementation 19. Internal inspection, monitoring, and evaluation systems 20. Grievance, remediation, and transparency mechanisms 21. Product traceability and documentation systems 22. Digitalisation, geolocation, and farm mapping systems 23. Stakeholder participation in governance and decision-making
Culture	24. Gender equality and women's empowerment 25. Youth participation in agriculture 26. Protection of human rights and labour rights 27. Prevention of discrimination, violence, and harassment 28. Prevention of child labour and forced labour 29. Freedom of association and strengthening social cohesion. 30. Community participation and local community empowerment 31. Preservation of local values, traditions, and indigenous knowledge
Infrastructure	32. Agricultural processing and storage infrastructure 33. Irrigation and water conservation infrastructure 34. Waste management and sanitation infrastructure 35. Occupational health, safety, and worker housing infrastructure 36. Information technology and agricultural digitalisation infrastructure 37. Traceability infrastructure and certification data systems 38. Energy infrastructure and energy efficiency 39. Training, extension, and technical service infrastructure

Source: Rainforest Alliance (2020)

4. CONCLUSION

The findings demonstrate that the sustainability of the Subak system depends not only on ecological conservation and cultural preservation, but also on the capacity of farming communities to sustain their livelihoods within a rapidly changing economic environment.

Multifunction and Ecosystem Threats: Traditional rice fields play a broad range of multifunctional roles, from ecological functions (flood mitigation, biodiversity conservation, and climate regulation) to socio-cultural functions. However, its existence is seriously threatened by massive land conversion for tourism accommodation, damage to irrigation infrastructure caused by commercial development, and economic inequality, in which farmers bear the burden of maintaining aesthetic landscapes without receiving fair financial compensation.

Farmers' Perception and Readiness: Local farmers (krama subak) have a very good perception (80.48%) of the urgency of strengthening traditional institutional systems in the face of tourism expansion and socio-economic change. This is supported by a high level of knowledge (74.86%) and a strongly agree attitude (86.09%) to develop Subak's dual role, namely maintaining traditional irrigation management while managing the agribusiness unit professionally.

Adaptive Institutional Integration Model: Adopting the successful implementation of dual roles in Subak Guama, the Jatiluwih Kertha Agroecotourism Cooperative has been established and integrated into the organisational structure and customary law (awig-awig) of Subak Jatiluwih in a participatory manner. This cooperative serves as an operational instrument to manage agricultural input retail business units, microfinance, and the marketing of local red rice products, thereby distributing modern economic income directly to the farming community in a fair manner.

The long-term sustainability of Subak as a UNESCO World Cultural Heritage site requires a holistic approach grounded in the Multiaspect Sustainability Analysis (MSA) framework. Strengthening does not rely solely on economic and environmental aspects (such as organic agricultural restoration and hydrological cycle management), but also on modern infrastructure, strengthening traditional legal institutions, and cultural aspects through the involvement of young people to overcome labour shortages in the future. Ultimately, the resilience of Subak as a living cultural landscape will depend on maintaining a balance among conservation objectives, institutional adaptation, and the well-being of the communities that sustain it.

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