

# Review of Sustainability Criteria for Paddy Farming in Malaysia Based on Environmental, Economic and Social Dimensions

Mohammad Shafie Hairal Anam<sup>1</sup>, Alawi Sulaiman<sup>1,2\*</sup>, Abdul Kadir Othman<sup>3</sup>, Nabila Farhana Jamaludin<sup>4</sup>

<sup>1</sup>Faculty of Plantation and Agrotechnology, University Technology MARA Melaka Branch, 77300 Merlimau, Melaka, Malaysia

<sup>2</sup>Institute of Leadership and Development, University Teknologi MARA, Lebu Enstek, Bandar Enstek, 71760 Nilai, Negeri Sembilan Malaysia

<sup>3</sup>Institute of Business Excellence (IBE) Kompleks Al-Farabi Aras 4, Akademik 2 University Teknologi MARA (UiTM) 40450 Shah Alam Selangor, Malaysia.

<sup>4</sup>Chemical Engineering Department, University Teknologi Petronas, 32610 Perak, Malaysia.

\*Corresponding Author

DOI: <https://dx.doi.org/10.47772/IJRISS.2025.9010113>

Received: 29 December 2024; Accepted: 02 January 2025; Published: 05 February 2025

## ABSTRACT

This review is a comprehensive effort to recommend appropriate sustainability criteria for paddy farming practices in Malaysia. This study compared sustainability criteria on five (5) major sustainability documents namely Sustainability Assessment of Food and Agriculture Systems (SAFA), Roundtable Sustainable Palm Oil (RSPO), Malaysian Sustainable Palm Oil (MSPO), Malaysia Good Agricultural (MyGAP) and Sustainable Rice Platform Standard (SRP). Data extraction and content analysis were conducted using NVivo 15 software. The findings revealed 12 criteria for the environmental dimension; Zero burning practices, Water resources, Soil quality, Replanting, Harvesting and Post-harvesting, Efficiency of energy use, Waste management and disposal, Planting material, Pest Input control, Ecosystem diversity, species diversity, eight (8) criteria for economic dimension; Profitability, Traceability, Stability of Production, Stability of Supply, Liquidity, Risk management, Value creation, Local procurement and seven (7) criteria for social dimensions; Quality of life, capacity development, fair access to means of production, Right to use land, Employment conditions, Living conditions and Workplace safety recommend for paddy cultivation practices. In conclusion, this review has provided new sustainability criteria for paddy cultivation practices which could be used as a guide for farmers and policymakers in making informed decisions to improve sustainability in paddy cultivation in Malaysia.

**Keywords:** Sustainability Criteria, Sustainable, Guideline, Sustainability Framework, Sustainable Indicator, Paddy Farmer

## INTRODUCTION

In Malaysia, paddy yield and output are viewed as critical success factors in the paddy cultivation process. In the late 2000s, concerns and awareness of food security and sustainability increased [32]. As production costs rise yearly while yields and profits decline or follow a static pattern, stakeholders and farmers are increasingly concerned about the sustainability of paddy production and yield stability [16]. Due to immigration from neighbouring countries and population expansion, Malaysia's paddy industry plays a significant role in the country's ability to provide jobs, nourishment, and substantial economic benefits [32,11]. In the Twelfth Malaysia Plan (RMK12) 2021–2025, Malaysia aims to attain its food security target of 75% paddy self-sufficiency level [30]. Currently, there are approximately 189,500 paddy farmers in Peninsula Malaysia, Sabah and Sarawak [10].

Sustainability is a multidimensional concept [28] of a dignified life for the present without compromising a dignified life in the future or endangering the natural environment and ecosystem services [5]. Its evaluation process is important in developing and promoting sustainable agricultural systems [6]. To investigate the transition towards more sustainable production, various frameworks have been proposed to gain knowledge

about the sustainability performance of such production systems [20]. Some frameworks are based on indicators, whereas others are based on indices [25]. Indicator-based sustainability assessment frameworks combining environmental, economic and social issues require the processing of a wide range of information (qualitative vs. quantitative), parameters and uncertainties [26]. They also differ in scope, target audience, indicator selection, aggregation, weighting and scoring methods, as well as the time required to complete the assessment [12]. Although many frameworks emphasize the necessity of including socio-economic and environmental aspects in sustainability assessment, many others focus only on environmental indicators to investigate the short- and long-term effects of different agricultural management practices [21]. In addition, existing assessment methodologies to investigate agricultural sustainability are scattered, focusing on single, complicated and demanding aspects regarding time, cost and required skills [3].

Malaysia Good Agricultural Practices (MyGAP) and Malaysian Sustainable Palm Oil (MSPO) were created to convey international sustainability agriculture practices. However, MyGAP was a general sustainable agriculture framework for agriculture producers in Malaysia and MSPO was a specific sustainability guideline for oil palm producers. Thus, there is a lack of sustainability framework or guidelines for paddy production in Malaysia. Thus, the main aim of this paper is to review sustainability criteria standards and frameworks used to assess sustainability in agricultural areas for paddy cultivation. The specific aims are (i) to identify specific sustainability agriculture standards, guidelines, and framework; (ii) to summarise and compare the availability of criteria in each standard, guideline, and framework; and (iii) to synthesise and summarise sustainability criteria relevant adapted in paddy farmer cultivation practices in Malaysia.

## METHODOLOGY

In this study, a literature review approach was used to recommend sustainability criteria for paddy cultivation practices at the farm level in Malaysia granary based on reviewed sustainability standards or guidelines or frameworks. The literature search used purposive sampling [33,34], in which five (5) major sustainability standards, guidelines and frameworks were identified namely Malaysian Sustainable Palm Oil (MSPO), Roundtable Sustainable Palm Oil (RSPO), Sustainability Assessment of Food and Agriculture Systems (SAFA), Sustainable Rice Platform (SRP) and Malaysia Good Agricultural Practices (MyGAP). MSPO and MyGAP were chosen because the standards were developed specifically for Malaysia agriculture practices and fit the scope of this study. RSPO was chosen for its relation to MSPO and the context of the practice specific to tropical region crops and world-renowned palm oil standards. The SAFA framework was selected for its general world agriculture assessment guideline to counterbalance other sustainability standards. The SRP standard was chosen for context specific to paddy cultivation in tropical regions.

The NVivo 15 software was used for data extraction of sustainability standards, guidelines and frameworks. The extracted data was organized into categories into environmental, social and economic dimensions with their respective elements. The content analyses [24], were performed where relevant themes and coding as criteria and indicators were identified. Further, the content analysis result was synthesized for comparison between criteria, alignment with current paddy farming practices and recommended sustainability criteria in the discussion section. The flowchart of the overall methodology performed is shown in Fig. 1.

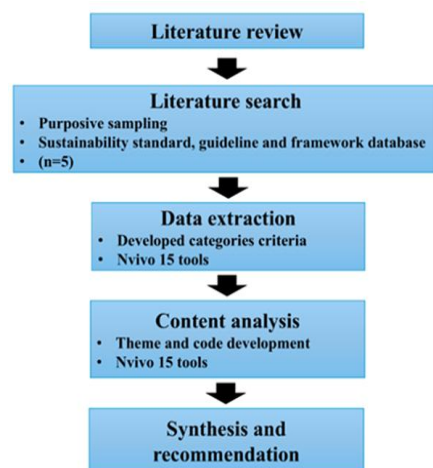


Fig. 1. Literature review approach flowchart created by the author

## RESULT AND DISCUSSION

**1) Sustainability standard, guideline and framework:** The standards have been analysed for their relevance to sustainability challenges faced by paddy farmers in Malaysia. Every standard contributes to sustainability differs from each other. The MSPO standard handles environmental, social and economic dimensions by focusing on plantation practices, which focus on environmental conservation, social well-being, and economic resilience. MyGAP was developed specifically for Malaysian agriculture practices by integrating environmental and social. However, this standard scope is general and focuses more on commodities crops, with limited direct application to paddy cultivation.

SRP standard was the most relevant for paddy cultivation in Malaysia. This standard focused on sustainable issues such as water efficiency, nutrient management, biodiversity conservation and worker wellbeing. Alignment with current issues faced by paddy cultivation in Malaysia, such as open burning residue [22] and high-water consumption [19]. With adoption of sustainability criteria based on SRP standards with local practices, increased the proposed criteria that are comprehensive in tackling the sustainability issue.

SAFA framework developed by the Food and Agriculture Organization of the United Nations provided the most comprehensive general guidance to the world for the agriculture sector (FAO, 2014). These frameworks are larger in scope and provide adaptation across the agriculture sector. However, it still needs to be modified to suit the context of a region ([12, 21]). Thus, adapted sustainability criteria based on SAFA frameworks show Malaysia's paddy sector embraces the world agenda.

Moreover, the RSPO standard was the most comprehensive standard for palm oil smallholders and a world-renowned standard in Palm oil-producing countries. Which focuses on oil palm plantation cultivation, and provides guidelines on worker rights, equality and environmental sustainability. The standard combines fair trading practices for smallholder and environmental conservation, which is suitable for paddy cultivation to reduce worker exploitation and environmental degradation. The detailed information of review sustainability standards, guidelines and framework based on detailed names, organizations, regions and references retrieved as shown in Table 1.

Name	Organization	Region	Reference
Guidance Document MS2530-2-1:2022 Malaysian Sustainable Palm Oil (MSPO)- Part 2-1: General Principle for Independent Smallholder (Less Than 40.46 Hectares	Malaysia Sustainable Palm Oil (MSPO)	Malaysia	mspo.org.my
Sustainability Assessment of Food and Agriculture Systems (SAFA) Guidelines	Food And Agriculture Organization of the United Nations (FAO UN)	World	fao.org
Sustainable Rice Platform (SRP) Standard for Sustainable Rice Cultivation	Sustainable Rice Platform (SRP)	World	SustainableRice.org
Roundtable Sustainable Palm Oil (RSPO) Independent Smallholder Standard	Roundtable on Sustainable Palm oil	World	rspo.org
Malaysia Good Agricultural Practices (MyGAP) – Crop production (Malay Version)	Department of Agriculture Malaysia, Ministry of Agriculture and Food Security	Malaysia	doa.gov.my

**2) Summary of sustainability dimension categories.** The summary of review findings on sustainability standards, guidelines and framework categories is shown in Table 2 below. The ‘Type of file’ indicates the type of sustainability standard, guideline and framework categories into dimensions and elements.

Dimension	Element	Type of file
Environment	Air	All standard
	Water	MSPO, MyGAP, SAFA, SRP
	Land	All standard
	Material and energy	All standard
	Biodiversity	All standard
Economic	Investment	All standard
	Local Economy	SAFA, RSPO, MSPO
	Vulnerability	SRP, MyGAP, SAFA
	Product quality & Information	All standard
Social	Cultural Diversity	All standard
	Decent Livelihood	SAFA
	Equity	All standard
	Fair Trading Practices	SRP, RSPO, SAFA
	Labor right	All standard
	Human Safety & Health	All standard

Table 2 shows the categories of sustainability dimensions of environmental, economic and social with their respective elements and specific criteria. This dimension was established as guidance in sustainability assessment and focused on specific aspects of practices. Water, soil quality and air are universally important agriculture practices in sustainability. In the context of Malaysian paddy cultivation, one of the elements such as air (zero burning practice) is very important in reducing greenhouse gases for environmental conservation due to open burning in paddy cultivation in Malaysia [17]. This shows zero burning practices for element air highlight the importance for reducing environmental impact of paddy cultivation.

The economic dimension focuses on investment, local economy, vulnerability, product quality and information. Investment was an important factor for paddy farmers, which they needed to manage their finances properly. Financial literacy and accounting practices are important for economic resilience [15]. Moreover, vulnerability is also one of the important elements for paddy farmers in preparation for predictive risk in paddy cultivation. Liquidity and risk management show the need for economic resilience, especially when facing input price fluctuation and climate change ([36],[37]).

Social dimensions involve elements of labour rights, quality of life, equity, fair trading practices, human health and safety. This element is important for improving and maintaining social well-being in paddy cultivation areas and longevity of good agricultural practices. Workplace safety and capacity development are important in encouraging paddy farmers to conduct sustainable practices [22]. Thus, tackling the social dimension needs specific action such as training programs, equitable distribution of resources, and maintaining labour well-being.

**3) Theme and code development:** The content analysis showed that the developed criteria as the theme and the number of indicators as code followed the categories. A total of 15 Elements and 42 Criteria were created, and 222 indicators were reviewed and arranged with their respective Element and Criteria. Further information on code refers to the additional information section. The developed theme and code under its categories as shown in Table 3.

Table 3 Developed theme and code			
Dimension	Element	Criteria (Theme)	No of Indicator (Code)
Environment	Air	Zero Burning practices	5
		Air pollution	3
	Water	Water resources	9
	Land	Soil quality	5
		Replanting	10
		Harvesting and post-harvesting	7
	Materials and Energy	Efficiency of energy and renewable energy use	2
		Waste management and disposal	5
		Planting material	4
		Pest Input	5
		Fertilizer Input	7
	Biodiversity	Ecosystem diversity	5
		Species diversity	8
		Genetic Diversity	13
	Economic	Investment	Profitability
Community investment			2
Long-ranging investment			11
Internal investment			3
Vulnerability		Stability of Production	11
		Stability of supply	2
		Stability of Market	5
		Liquidity	5
		Risk management	1
Product quality & information		Food quality	18
		Food safety	7
	Production Information	6	

	Local Economic	local Procurement	1
		Value Creation	2
Social	Decent livelihood	Quality of Life	3
		Fair Access to Means of Production	12
		Capacity development	6
	Fair trading practices	Responsible Buyers	6
		Right of suppliers	3
	Labor right	Living condition	3
		Employment condition	2
	Equity	Gender equality	4
		Non-Discrimination	2
		Support to Vulnerable People	3
	Human Safety & Health	Public health	2
		Workplace safety	2
	Cultural Diversity	Food Sovereignty	13
Indigenous Knowledge		1	

Based on Table 3, every theme represents an important aspect of sustainability, with the code acting as a measurable indicator. One of the themes representing the environmental dimension was the zero burning practices indicator that involves paddy straw and stubble management, which shows the need for reduction of air pollution and increasing soil health [17]. In the economic dimension, profitability and stability of production themes overcome the financial challenges of paddy farmers. Positive profit and lower expenses show economic resilience and efficiency. Integrating this indicator into sustainability assessment ensures that agriculture practices are environmentally friendly and economically competitive [15].

Social dimension themes such as quality of life and labour rights show overcoming challenges of social sustainability. Quality of life indicators including access to education, health care and fair wages indicate long-term positive outcomes for social fairness and community development. Capacity development important theme focused on the need for training and skill development to encourage paddy farmer practices technology and sustainable practices [4].

**4) Comparative of criteria across sustainability standards;** Comparison of mentioned criteria based on the mentioned five (5) sustainability standards and guidelines in agriculture. “√” indicated mentioned and “X’ is not mentioned in the sustainability standard and guidelines. The standard indication for MSPO (A), MyGAP (B), RSPO (C), SAFA (D) and SRP (E). The comparison scoring is shown in Table 4.

Table 4						
Comparison scoring based on their dimension and criteria						
Dimension	Criteria	Standard				
		A	B	C	D	E
Environment	Zero Burning practices	√	√	√	X	√



	Air pollution	√	X	X	√	X
	Water resources	√	√	X	√	√
	Soil quality	√	X	√	√	√
	Replanting	√	√	√	√	√
	Harvesting and post-harvesting	√	√	X	X	√
	Efficiency of energy and renewable energy use	√	X	X	√	X
	Waste management and disposal	√	√	√	√	√
	Planting material	√	√	√	X	√
	Pest input	√	√	√	√	√
	Fertilizer input	√	√	√	√	√
	Ecosystem diversity	√	√	√	√	√
	Species diversity	√	√	√	√	√
	Genetic diversity	X	X	X	√	X
	<b>Total</b>	<b>13</b>	<b>10</b>	<b>9</b>	<b>11</b>	<b>11</b>
Economic	Profitability	√	X	X	√	X
	Community investment	√	√	√	√	X
	Long-ranging investment	√	X	√	√	X
	Internal investment	√	√	√	√	√
	Stability of Production	√	X	X	√	X
	Stability of supply	√	X	√	√	X
	Stability of Market	√	X	√	√	X
	Liquidity	X	X	X	√	X
	Risk management	√	√	√	√	√
	Food quality	X	√	X	√	√
	Food safety	X	√	X	√	√
	Production Information	X	X	X	√	X
	local Procurement	√	X	X	√	X
	Value Creation	√	X	√	√	X
	<b>Total</b>	<b>10</b>	<b>5</b>	<b>7</b>	<b>14</b>	<b>4</b>
Social	Quality of Life	√	X	X	√	X
	Fair Access to Means of Production	√	√	√	√	X
	Capacity development	√	X	√	√	X
	Responsible Buyers	√	√	√	√	√
	Right of suppliers	√	X	X	√	X
	Living condition	√	X	√	√	X
	Employment condition	√	X	√	√	X

Gender equality	X	X	X	√	X
Non-Discrimination	√	√	√	√	√
Support to Vulnerable People	X	√	X	√	√
Public health	X	√	X	√	√
Workplace safety	X	X	X	√	X
Food Sovereignty	√	X	X	√	X
Indigenous Knowledge	√	X	√	√	X
<b>Total</b>	<b>10</b>	<b>5</b>	<b>7</b>	<b>14</b>	<b>4</b>

Based on Table 4, it shows the differences in focus and usability of the standard. In environmental dimensions, MSPO was the most comprehensive standard focusing aspect on this dimension. However, it focuses on palm oil cultivation which limits the usability of its criteria directly into paddy cultivation. Similar to RSPO, which is less comprehensive than MSPO. SAFA, MyGAP and SRP have close similarities in terms of their comprehensiveness but lower than MSPO, but their criteria were general and easily adapted for paddy cultivation.

Further, in social and economic SAFA is the most comprehensive compared to all sustainability standards offered such as accountability, transparency, human safety and health etc. However, its global scope does not consider the local context [20]. SRP standards that focus on paddy help in reducing this gap from other standards and act as benchmarks such as water and nutrient management. With the integration of these elements from this framework, one specific criterion that comprehensive focusing Malaysian content could be developed for paddy cultivation.

**5) Relevant adaptations for rice cultivation:** Relevant of reviewed sustainability criteria based on sustainability standards and guidelines adapted in Malaysia Paddy cultivation at farm level focusing farmer practices in granary area as 1) relevant (√), 2) not relevant (X), and 3) not mentioned (-). The standard indication for MSPO (A), MyGAP (B), RSPO (C), SAFA (D) and SRP (E). The applicability of the selected criteria is shown in Table 5.

Dimension	Criteria	Standard				
		A	B	C	D	E
Environment	Zero Burning practices	√	√	√	-	√
	Air pollution	X	-	-	X	X
	Water resources	√	√	-	√	√
	Soil quality	√	-	√	√	√
	Replanting	√	√	√	√	√
	Harvesting and post-harvesting	√	√	-	-	√
	Efficiency of energy and renewable energy use	√	-	-	√	√
	Waste management and disposal	√	√	√	√	√
	Planting material	√	√	√	-	√
	Pest input	√	√	√	√	√
	Fertilizer input	√	√	√	√	√



	Ecosystem diversity	√	√	√	√	√
	Species diversity	√	√	√	√	√
	Genetic diversity	-	-	-	<b>X</b>	-
Economic	Profitability	√	-	-	√	√
	Community investment	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
	Long-ranging investment	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
	Internal investment	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
	Stability of Production	√	-	-	√	√
	Stability of supply	√	-	√	√	√
	Stability of Market	<b>X</b>	-	<b>X</b>	<b>X</b>	<b>X</b>
	Liquidity	-	-	-	√	-
	Risk management	√	√	√	√	√
	Food quality	-	<b>X</b>	-	<b>X</b>	-
	Food safety	-	<b>X</b>	-	<b>X</b>	-
	Production Information	-	-	-	<b>X</b>	-
	local Procurement	√	-	-	√	√
	Value Creation	√	-	√	√	√
Social	Quality of Life	√	<b>X</b>	<b>X</b>	√	<b>X</b>
	Fair Access to Means of Production	√	√	√	√	√
	Capacity development	√	√	√	√	√
	Responsible Buyers	√	√	√	√	√
	Right of suppliers	<b>X</b>	-	<b>X</b>	<b>X</b>	<b>X</b>
	Living condition	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
	Employment condition	<b>X</b>	<b>X</b>	-	-	<b>X</b>
	Gender equality	√	-	√	√	√
	Non-Discrimination	-	-	<b>X</b>	<b>X</b>	-
	Support to Vulnerable People	-	-	√	√	-
	Public health	-	-	-	<b>X</b>	-
	Workplace safety	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
	Food Sovereignty	√	√	√	√	√
	Indigenous Knowledge	-	-	-	<b>X</b>	-

Based on Table 5, zero burning practice is very relevant to Malaysian paddy farmer sustainability practices due to their practices and issues. The practices of zero burning have been stated in the Malaysia Rice Check Guideline

[10], and issues arise with paddy in Malaysia such as paddy straw is presently disposed of primarily by open burning, which results in the release of various pollutants affecting the environment, weather and local communities [17], lack of pro-environmental behaviour among paddy farmers [4] and 45 % of locals reported air pollution from residue burning at Selangor [22]. Thus, all indicator standards have been adopted. However, rice straw and stubble were chosen due to being more specific to paddy practices. However, still, elements of zero burning driven from MyGAP, MSPO, and RSPO were adopted in the selected indicator.

Criteria for air pollution, with its indicator under the element of air and the environmental dimension aligned with Malaysia's paddy production context. However, the criteria were eliminated due to its scale being unsuitable for paddy farmers implemented due to capabilities to mitigate greenhouse gas emissions (GHG). Due to their systematic management, the criteria are relevant to be adopted for bigger enterprises, agencies, or groups of farmers.

Further, criteria for water resources with its indicator under the element of water and the environmental dimension as the water management practices have been stated in the Malaysia Rice Check Guideline [10]. Issues arise, such as water deprivation for rice, which is higher in Penang than in other states due to higher levels of water stress and amount of water withdrawal [8] resources. In Malaysia, the largest freshwater withdrawal of more than 75% is for irrigation in the agriculture sector and is mainly confined to irrigated rice production [19]. Thus, all indicator standards have been adopted. However, water management and drainage were chosen due to more specific paddy practices. Still, water management elements driven by MyGAP, MSPO, and SAFA were adopted in the selected indicator.

Criteria for soil quality under the element of land and the environmental dimension. The practices of soil quality have been stated in the Malaysia Rice Check Guideline [10], and issues such as the plantation areas in other rice-producing states, including Sabah and Selangor, were also studied for heavy metals contamination on paddy soils and rice [23]. The management of this hard soil layer is less emphasized by paddy farmers because they focus a lot on soil fertility and care of rice crops, such as fertilisation rate, pesticide spray rate, type of fertiliser, and so on [9]. Thus, all indicator standards have been adopted. However, heavy metal and soil salinity were chosen due to being more specific to paddy practices, but still, elements of water management driven from MyGAP, MSPO, and SAFA were adopted in the selected indicator event, and its indicator was general.

Criteria replanting with its indicator under the element land and the environmental dimension. The practices of replanting management have been stated in the Malaysia Rice Check Guideline [10], and issues arise, such as non-compliance with the Malaysia Rice Check Guideline from 80 paddy farmers, eight farmers practised quite an unsustainable paddy farming with a score of less than 40.0 on a scale of 0–100 [13], and farmers do not follow perfectly cultivation manual suggested by the DOA [29]. Thus, all indicator standards have been adopted. However, levelling, nutrient management, and specific field boundaries adopted from Malaysia Rice Check Guideline and SRP were chosen due to more specific to paddy practices, but still, elements of replanting management driven from MyGAP, MSPO, and SAFA adopted in the selected indicator were general.

Criteria harvesting and post-harvesting, with its indicator under the element of land and the environmental dimension. The practices of harvesting and post-harvesting practices have been stated in the Malaysia Rice Check Guideline [10]. Issues arise from criteria five, such as non-compliance with the Malaysia Rice Check Guideline. Of 80 paddy farmers, (80%) practised entirely unsustainable paddy farming with a score of less than 40.0 on a scale of 0–100 [13], and farmers did not follow the low-perfect cultivation manual suggested by the DOA [29]. Thus, all indicator standards have been adopted. However, drying technique, drying time, harvest equipment, post-harvest handling, and timing of harvest adopted from Malaysia Rice Check Guideline, MyGAP, and SRP were chosen due to more specific to paddy practices but still elements of replanting management driven from MSPO adopted in the selected indicator was general.

Criteria efficiency of energy use and the use of renewable energy with its indicator under the element of materials and energy and the environmental dimension. The efficiency of energy use and use of renewable energy practices have been stated in the Malaysia Rice Check Guideline [10], and the issue arises that farmers in granary areas in Malaysia depend on non-renewable fossil-based fuel, forming around 84% of the total energy input [14]. This shows a concerning negative impact on the environment and the high price of non-renewable fuel. Thus, all indicator standards have been adopted. However, the efficiency of energy use and use of renewable energy

adopted from MSPO was chosen due to being more specific to paddy practices. However, it is still an element of energy use practices driven by SAFA that was adopted in the selected indicator. Further, current Malaysian sustainable practices paddy farmers did not mention these indicators.

Criteria waste management and disposal, with its indicator under the element of materials and energy and the environmental dimension. The practices of waste disposal have been stated in the Malaysia Rice Check Guideline [10], and issues arise, such as the low awareness level on how to dispose of used pesticide containers [19]. Thus, all indicator standards have been adopted. However, waste management and reuse waste were adopted from MyGAP, MSPO, and SRP were chosen due to being more specific to paddy practices, but still, the element of replanting management driven from SAFA and RSPO adopted in the selected indicator event its indicator was general.

Criteria planting material with its indicator under element materials and energy under environmental dimension. The practices of planting material selection have been stated in the Malaysia Rice Check Guideline [10]; however, no issue of uncertified planting material used by paddy farmers is found in the literature. During the assessment, the researcher adopts these criteria to indicate the use of certified planting material for all paddy farmers in granary and non-granary areas. Thus, all indicator standards have been adopted. However, pure-quality seeds adopted from SRP were chosen because they were more specific to paddy practices. However, elements of planting material driven from MSPO, RSPO, and MyGAP adopted in the selected indicator were general.

Criteria fertilizer input, which is an indicator under the materials and energy element and environmental dimensions. The practices of fertilizer consumption have been stated in the Malaysia Rice Check Guideline [10], and issues arise such that the sustainability level in the paddy farming practices is still relatively low, implying that farmers are not following the Paddy Check guideline and are using excessive fertilizer [13]. Thus, all indicator standards have been adopted. However, Inorganic fertilizer and Organic fertilizer specific field boundary adopted from Malaysia Rice Check Guideline and SRP were chosen due to more specific to paddy practices but still an element of replanting management driven from MyGAP, MSPO, RSPO, and SAFA adopted in the selected indicator was general.

Criteria pest input control, which is an indicator under the element of materials and energy and the environmental dimension. The practices of pesticide and biological control pests have been stated in the Malaysia Rice Check Guideline [10], and issues arise, such as increased use of pesticides on rice fields in Malaysia [7] and excessive usage of pesticides that can harm the farmers' health [22]. Thus, all indicator standards have been adopted. However, chemicals control pest and biological pest control specific field boundaries adopted from SRP and MyGAP were chosen due to more specific to paddy practices, but still, elements of replanting management driven from MSPO, RSPO, and SAFA adopted in the selected indicator were general.

Criteria ecosystem diversity with its indicator under the element of biodiversity and the environmental dimension. The practices of ecosystem diversity have been stated in the Malaysia Rice Check Guideline [10], and a lack of issues has been found in the literature on the impact of paddy farmer practice on ecosystem diversity. Thus, all indicator standards have been adopted. However, land conversion and vacant sites' specific field boundaries adopted from SRP were chosen due to more specific paddy practices. Still, elements of ecosystem diversity driven by MyGAP, MSPO, RSPO, and SAFA adopted in the selected indicator were general.

Criteria species diversity, with its indicator under the biodiversity element in the environmental dimension. The practices of species diversity have been stated in the Malaysia Rice Check Guideline [10]. Issues arise, such as the sustainability level in the paddy farming practices is still relatively low, implying that farmers are not following the Paddy Check guidelines using excessive fertilizer [13]. About 80% of the farmers state that the decreasing number of freshwater fish on account of pesticide use, the nature of twice-a-year cultivation [7], and excessive usage of pesticides can harm the farmers' health [22]. Thus, all indicator standards have been adopted. However, Invasive species and Integrated Pest Management (IPM) adopted from SRP, MSPO, and RSPO were chosen due to being more specific to paddy practices, but still, the element of Species diversity driven from SAFA adopted in the selected indicator was general.

Criteria genetic diversity, which is an indicator of the biodiversity element in the environmental dimension.

Genetic diversity practices are not stated in Malaysia's rice check guidelines, and the lack of genetic diversity in Paddy farmer cultivation practices is found in the literature. Thus, the criteria have been eliminated.

Criteria profitability, with its indicator under the investment element and in the economic dimension. The practices of profitability have not been stated in the Malaysia Rice Check Guideline [10], and issues arise, such as rising costs of rice cultivation [16] and lack of financial help and understanding, small-scale producers choose to use traditional agricultural practices [11]. Thus, all indicator standards have been adopted. However, net income, cost of production, and price determination adopted from SAFA were chosen because they are more specific to paddy practices. Still, the investment elements driven by MSPO adopted in the selected indicator were general.

Criteria community investment, long-ranging and internal investment with its indicator under element investment under the economic dimension. The practices have not been stated in the Malaysia Rice Check Guideline [10], and the criteria are not adapted to paddy farmers because rice farmers cannot meet these criteria, which can only be achieved by bigger organisations. Thus, the criteria for proposing current practices have been eliminated.

Criteria stability of production, with its indicator under the element vulnerability in the economic dimension. The practices of stability of production have not been stated in the Malaysia Rice Check Guideline [10]. Without financial help and understanding, small-scale producers use traditional agricultural practices [11]. Thus, all indicator standards have been adopted. However, a guarantee of production levels adopted from SAFA was chosen due to being more specific to paddy practices, but still, the element of stability of production driven by MSPO adopted in the selected indicator was general.

Criteria stability of supply, with its indicator under the element of vulnerability in the economic dimension. The practices of stability of supply have not been stated in the Malaysia Rice Check Guideline [10], and issues such as shortage of rice seeds happen every year due to many factors such as logistical and management problems and seed supplies arriving late. Planting is dragged off-season, and disease, supply, and demand mismatch producers and retailers forcefully promoting certain seed varieties that are more profitable, like MR220 CL2, as well as profiteering and hoarding, as reported by the media and farmers' organisations [2]. Thus, all indicator standards have been adopted. However, procurement Channels, Stability of Supplier Relationships, and Dependence on the Leading Supplier adopted from SAFA were chosen due to more specific to paddy practices, but an element of Stability of Production driven from MSPO and RSPO adopted in the selected indicator was general.

Criteria market stability, with its indicator under vulnerability and the economic dimension. The practices of market stability have not been stated in the Malaysia Rice Check Guideline [10], lacking issues in literature faced by paddy farmers and these criteria applicable to bigger organisations. Thus, the researcher has eliminated these criteria.

Criteria liquidity, which is an indicator of the element of vulnerability under economics. The practices of liquidity have not been stated in the Malaysia Rice Check Guideline [10]. Still, issues arise, such as paddy farmers being unaware of what a specialized accounting record the paddy should have for them [15]. Thus, the liquidity indicator has been adopted in the proposed sustainability criteria based on only one sustainability guideline mentioned. The indicator was SAFA.

Criteria risk management, with its indicator under the element vulnerability in economics. The practices of risk management have not been stated in the Malaysia Rice Check Guideline [10]. There is an issue in the literature on the stability of supply faced by paddy, but this criterion has the potential to be proposed for the economic dimension. Thus, risk management adopted from SAFA was chosen to represent all standards for paddy farmer practices from MSPO and RSPO in terms of economic dimension.

Criteria food quality, food safety, production information, and local procurement under product quality & information element. The criteria practices have not been stated in the Malaysia Rice Check Guideline [10], lacking issues in literature faced by paddy farmers and these criteria applicable to bigger organisations or factories. Thus, the researcher has eliminated these criteria.

Criteria value creation with its indicator under the element of the local economy under the economic dimension. These practices have not been stated in the Malaysia Rice Check Guideline [10] and are lacking issues found in literature faced by paddy farmers. Thus, regional and regional workforce indicators have been adopted based on SAFA. However, still, the element of Value Creation driven from MSPO adopted in the chosen indicator event its indicator was general.

Criteria quality of life, with its indicator under the element of a decent livelihood in the social dimension. The practices of quality of life have not been stated in the Malaysia Rice Check Guideline [10]. The current quality of life (QoL) situation in rural areas could not fulfil the expectations of some farmers from a higher education background, especially those living on the East Coast who do not have part-time jobs alongside paddy farming [27]. Thus, all indicator standards have been adopted. However, the right to quality of life and wages adopted from SAFA and SRP were chosen because they were more specific to paddy practices. However, the quality of life adopted from MSPO in the chosen indicator was general.

Criteria fair access to means of production, with its indicator under the element of decent livelihood in the social dimension. The practices of access to means of production have not been stated in the Malaysia Rice Check Guideline [10] and are lacking issues found in literature faced by paddy farmers. Thus, all indicator standards have been adopted. However, access to production adopted from SAFA was chosen because it is more specific to paddy practices. However, it is still an element of quality of life driven by MSPO, SRP, SAFA, and MyGAP adopted in the chosen indicator. Its indicator was general.

Criteria capacity development, with its indicator under the element of decent livelihood in the social dimension. The practices of capacity development have not been stated in the Malaysia Rice Check Guideline [10] and lack issues found in literature faced by paddy farmers. Thus, these criteria were adopted to increase paddy farmers' knowledge of cultivation practices. All indicator standards have been adopted. However, capacity development adopted from SAFA was chosen because it is more specific to paddy practices. However, an element of quality of life driven by MSPO was adopted for the selected indicator. Its indicator was general.

Criteria responsible buyers and criteria 33 the right of suppliers, which indicates trading practices under the social dimension. The practices of responsible buyers have not been stated in the Malaysia Rice Check Guideline [10], and issues found in the literature between farmers and rice companies have caused conflicts regarding pricing issues [1]. However, the indicator is not proposed because it is unsuitable for assessing suppliers in paddy farmer practices due to different units of measure and pricing of input and yields not control by paddy farmers. The criteria were eliminated from the proposed criteria.

Criteria living conditions are an indicator of labour rights under the social dimension. The practices of Living conditions have not been stated in the Malaysia Rice Check Guideline [10], and no issue has been found in the literature faced by paddy farmers. Thus, all indicator standards have been adopted. However, Housing conditions adopted from MSPO were chosen under the element of labour rights, but still, the element of living conditions driven by RSPO was adopted.

Criteria employment condition with its indicator under the element of labour rights under the social dimension. The practices of employment conditions have not been stated in the Malaysia Rice Check Guideline [10], and no issue has been found in the literature faced by paddy farmers. Thus, all indicator standards have been adopted. However, employment relations, forced labour, discrimination, child labour, wages, and freedom of association adopted from MSPO were chosen under labour rights but still an element of Employment conditions driven from MSPO, RSPO, SRP, and SAFA adopted.

Criteria gender equality, with its indicator falling under the equity element in the social dimension. The. The practices of Gender equality have not been stated in the Malaysia Rice Check Guideline [10], and no issue was found in the literature faced by paddy farmers. Thus, the practices of gender equality are not suitable for paddy farmers because paddy farmers hire male labourers to help in paddy production. The criteria have been eliminated from the proposed criteria.

Criteria non-discrimination, with its indicator falling under the equity element in the social dimension. The practices of non-discrimination have not been stated in the Malaysia Rice Check Guideline [10], and no issue has been found in literature faced by paddy farmers. However, the non-discrimination practices are potentially



suitable for implementation by paddy farmers because they hire labour to help in paddy production. Discrimination adopted from MSPO, RSPO, and SRP was chosen under the element of labour rights.

Criteria support for vulnerable people, with its indicator under the element Equity under the social dimension. The support for vulnerable people practice has not been stated in the Malaysia Rice Check Guideline [10] and is not an issue found in literature faced by paddy farmers. Thus, the indicator is not proposed because it is unsuitable for paddy farmers who cannot support vulnerable people. The criteria were eliminated from the proposed criteria.

Criteria public health with its indicator under the element human safety & health under social dimension. The practices of public health have not been stated in the Malaysia Rice Check Guideline [10], and no issue has been found in the literature faced by paddy farmers. Thus, the indicator is not proposed because it is unsuitable for paddy farmers who cannot conduct public health contributions and assessments. The criteria have been eliminated from the proposed criteria.

Criteria workplace safety, with its indicator falling under the element of human safety & health in the social dimension. The practices of workplace safety have not been stated in the Malaysia Rice Check Guideline [10]. Issues in the literature, such as eight paddy farmers interviewed in Sekinchan Selangor, discovered they lack concern about occupational safety and health [4]. The fair performance of farmers who have not experienced health and safety issues is shown in 38% of the questionnaire's social assessment of 72 farmer participants [22]. However, safety instruction and first aid, tools and equipment, training of pesticide applicators, training of pesticide applicators, washing and changing, applicator restrictions, re-entry time, and pesticide and chemical storage adopted from MSPO, SRP, RSPO, MyGAP, and SAFA were chosen under element human safety & health.

Criteria food sovereignty and criteria 42 Indigenous Knowledge People, along with their indicators, fall under the element of cultural diversity in the social dimension. The practices of element cultural diversity have not been stated in the Malaysia Rice Check Guideline [10], and no issue has been found in the literature faced by paddy farmers. Thus, the indicator is not proposed because it is not suitable for assessing paddy farmer sustainability practices more on big organisations or enterprises. The criteria have been eliminated from the proposed criteria.

Regarding the governance dimension, the researcher did not include governance criteria in the current sustainability criteria due to focusing on environmental, social, and economic dimensions. However, two (2) of the governance dimension criteria are relevant to paddy farmers, such as criteria resource appropriation, and transparency. Other criteria in the governance dimension have been eliminated due to the low capabilities of paddy farmers to implement the criteria and are suitable for bigger enterprises. Thus, the criteria transparency with its indicator under the element accountability under the governance dimension has been adopted. The practice of transparency has not been stated in rice check guidelines, but it stated paddy farmers need to record their operation. Issues arise, such as paddy farmers being unaware of what a specialized accounting record the paddy should have for them [15] and the uncertified MyGAP certificate paddy farmers lack of time and knowledge as barriers to proper record-keeping for farm activities [4]. Thus, record keeping adopted from MSPO, SAFA, SRP, and MyGAP focuses on the economic dimension under element investment.

Criteria rule of law criteria, with its indicator under the element of accountability in the governance dimension being adopted. The practice rule of law has not been stated in rice check guidelines [10], and the lack of issues in the literature indicates that paddy farmers breach another landowner for cultivating paddy. However, these criteria shall be adopted to uphold the landowner's right to own land and reduce the cost of facing disputes. Thus, the rights to use land adopted from MSPO, SAFA, SRP, and MyGAP are an element of a decent livelihood for farmers in the social dimension.

**6) Proposed sustainability criteria for paddy farmer cultivation practices.** The selection of sustainability criteria is based on economic, social, and environmental dimensions, with consideration of two (2) criteria from the governance dimension due to their applicability. Criteria were selected based on the current practices of paddy farmers by referring to Malaysia Rice Check Guidelines and current issues faced and created by paddy farmers in the literature. Thus, 27 proposed criteria were selected that could be adopted in paddy farmers over 4.2 hectares of cultivation, as shown in Table 6 below.



Table 6 Summary of proposed sustainability criteria of paddy farmer over a 4.2-hectare paddy field

Dimension	Element	Criteria	Indicator
Environment	Air	Zero burning practices	Rice Stubble
			Rice Straw
	Water	Water resources	Water management
			Drainage
	Land	Soil quality	Heavy metals
			Soil Salinity
		Replanting	Levelling
			Field boundary
			Nutrient management
		Harvesting and post-harvesting	Timing of harvest
			Harvesting equipment
			Post-harvest handling
	Material And Energy	Efficiency of energy use and use of renewable energy	Energy consumption
			Management plan
		Reusing waste	
		Planting material	Pure quality seeds
		Pest Input control	Chemicals and biological control pest.
	Biodiversity	Ecosystem diversity	Inorganic and organic fertilizer
			Land conversion
		Vacant site	
Species Diversity		Invasive species	
		Integrated Pest Management (IPM)	
Economic	Investment	Profitability	Net income
			Cost of Production
			Price Determination
		Traceability	Record keeping
	Vulnerability	Stability of Production	Guarantee of production levels
			Procurement Channels
		Stability of Supply	Stability of Supplier Relationships
			Dependence on the Leading Supplier
		Liquidity	Net Cash Flow
			Safety Nets

		Risk Management	Risk Management
	Local economy	Value Creation	Regional Workforce
			Fiscal Commitment
		Local Procurement	Local Procurement
Social	Decent livelihoods of farmer	Quality of Life	Right to Quality of Life
			Wages
		Capacity Development	Capacity Development
		Fair Access to Means of Production	Access to production
		Right to use land	Proof of ownership
	Labour right	Employment condition	Employment relations
			Force labour
			Discrimination
			Child labour
			Wages
			Freedom of Association
		Living conditions	Housing
	Human safety & health	Workplace safety	Safety Instruction and first aid
			Tools and equipment
			Training of pesticide applicators
			Personal protective equipment (PPE)
			Washing and changing
			Applicator restrictions
			Re-entry time
Pesticide and chemical storage			

**7) Regional applicability with similar agricultural and socio-economic conditions.** The proposed sustainability criteria for paddy farmers over 4.2 hectares of cultivated land could be adopted like Malaysia's climate and socio-economic. However, the adaptation needs to consider the context-specific of a country due to the influence of its regulation, law and policy, and economic capabilities of each country. In terms of environmental dimension, similar agriculture practices faced environmental sustainability challenges such as air pollution, water scarcity, low soil fertility, overused input etc and not only on paddy cultivation but other crops. The proposed criteria such as zero-burning practices were aligned with the current global initiative as stated in Sustainable Development Goals to reduce greenhouse gases for agriculture impact. Open burning of agriculture residue is common around the world [(38,39)]. Encouraging farmers to conduct recycling practices and give incentives will ensure adaptation leads to pollution and wastage reduction [40]. Moreover, the term water management as stated in the proposed criteria was important, due to climate change. Adapting current efficient drainage and water conservation irrigation techniques such as alternate wetting and drying (AWD) improves farmer sustainability [41].

Furthermore, in terms of economic sustainability, economic resilience is important to encourage sustainable

practices. Profitability, risk management and traceability were relevant, especially for all paddy farmers. Examples such as record keeping, which gives valuable insight into farm operations. Farmer should keep their farm record to attract easy access to loans or subsidies from the government [42]. The loan incentive support by the government could help paddy farmer reduce their risk of natural disasters and unstable production.

The adoption of proposed social criteria needs align to specific country's culture and governance. Quality of life and the right to access land it relevant to all paddy farmers all over the world. Stated Sustainable Development Goals (SDGs) goal 3 good health and well-being and goal 16 peace, justice and strong institutions [43], indicate adapting the proposed criteria to another region was relevant due to the commitment of all countries supporting the SDGs goal. Paddy farmers' health and well-being are important criteria for each country, due to the issue of over-pesticide consumption [(44,45,46)], it is relevant to all countries. The focus of the criteria on safety, personal protection equipment, and storage of chemicals can be adapted directly. Thus, adaption of the proposed sustainability criteria for paddy farmer to other regions needs context specific to their own local environmental, economic and social need. Researchers and policymakers should consider the common issues faced in their region such as climate variation, resources and governance for implementation.

## CONCLUSION AND RECOMMENDATIONS

This review study presents an analysis and recommendation of sustainability criteria for paddy cultivation in Malaysia, which focuses on environmental, social and economic dimensions. Based on a thorough comparative study and analysis of the five (5) sustainability standards, guidelines and frameworks namely MSPO, RSPO, SRP, SAFA and MyGAP, this study identified 27 criteria that are suitable for further consideration. The findings of this study also suggested the importance of adapting international sustainability standards to the local contexts, which is also in line with current practice and mitigates agriculture issues such as open burning and overuse of input. This study also highlighted valuable insight that bridges the gap between international frameworks and the local agricultural context.

Paddy farmers should give serious attention to proposed practices for reducing environmental impact and maintaining economic resilience and social well-being of their paddy cultivation process. Policymakers are encouraged to give new capacity development programs that focus on educating paddy farmers in the form of physical and online modes of information exchange as well as supporting farmers with financial and subsidised incentives for renewable energy and the use of modern technology. Furthermore, the need for specific integrated guidelines such as the Sustainable Standard Rice Platform (SRP) with the Sustainability Assessment of Food and Agriculture Systems (SAFA) is suggested for promoting sustainable general assessment and ensuring practical relevance to paddy cultivation across Malaysia.

Future work should be conducted focusing on qualitative studies such as interviews with farmers, policymakers and agriculture experts who could express their opinions in more detail on the current issues in the development of the criteria. Moreover, expanding the study scope for all industry player assessment will overall view on sustainability in paddy production. With constant improvement and validation of these criteria, Malaysia could become the leading country in sustainable agriculture with an emphasis on economic resilience, environmental conservation and social well-being for its agriculture farmers.

## ACKNOWLEDGMENTS

This work was supported by the Research Management Centre (RMC), University Teknologi MARA, Malaysia through Geran Insentif Penyelidikan (GIP) 600-RMC/GIP 5/3 (109/2023).

## Conflict of Interest

No conflict of interest

## Additional Information

For additional detailed information in Table 3 and Table 6 please contact the corresponding author email [dr\\_alawi@uitm.edu.my](mailto:dr_alawi@uitm.edu.my)

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