UNIVERSITI TEKNOLOGI MARA

DEVELOPMENT OF A COMPREHENSIVE SUSTAINABILITY INDEX AND ASSESSMENT FOR SELECTED RICE FARMERS IN INTEGRATED AGRICULTURAL DEVELOPMENT AREA (IADA) NORTHWEST SELANGOR BASED ON ENVIRONMENTAL, ECONOMIC AND SOCIAL DIMENSIONS

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PhD

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Thesis submitted in fulfilment
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CONFIRMATION BY PANEL OF EXAMINERS

I certify that a Panel of Examiners has met on 29 April 2026 to conduct the final examination of Mohmmad Shafie bin Hairal Anam on his Doctor of Philosophy thesis entitled “Development of a Comprehensive Sustainability Index and Assessment for Selected Rice Farmers in Integrated Agricultural Development Area (IADA) Northwest Selangor Based on Environmental, Economic and Social Dimensions” in accordance with Universiti Teknologi MARA Act 1976 (Akta 173). The Panel of Examiners recommends that the student be awarded the relevant degree. The Panel of Examiners was as follows:

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ABSTRACT

Rice crops are vital for food security and sustainability in Malaysia. However, the industry continues to faced unsustainable cultivation practices, including poor farm financial management, occupational health and safety issues, environmental pollution, and vulnerability to environmental changes. These challenges undermine the environmental, economic, and social sustainability of rice production. Although several sustainability indices have been developed, existing indices for rice cultivation inadequately integrate environmental, economic, and social criteria, are insufficiently adapted to Malaysian cultivation practices and regulations, and lack systematic index construction procedures such as normalisation, weighting, and aggregation. Consequently, their usefulness as instruments for decision-making is still limited. This research aimed to (1) identify and analyse sustainability criteria and indicator for rice farmers based on environmental, economic, and social dimensions by referring to the current sustainability framework, cultivation practices and guidelines; 2) to validate the identified sustainability criteria based on contextual and practical relevant for rice farmers by referring to the opinion of experts in sustainability and rice cultivation; and 3) to assess the sustainability performance of rice farmer cultivation practices in and develop a sustainability index using mathematical algorithm. A mixed-methods approach was adopted. Sustainability criteria were identified through a rigorous review of the Sustainability Assessment of Food and Agriculture (SAFA), Malaysian Sustainable Palm Oil (MSPO), Roundtable on Sustainable Palm Oil (RSPO), Malaysian Good Agricultural Practice (MyGAP), and Sustainable Rice Platform (SRP) frameworks. Semi-structured interviews with experts in sustainability and rice cultivation validated the proposed criteria. Subsequently, face-to-face questionnaires were administered to 45 purposively selected rice farmers from nine IADA blocks in Kuala Selangor and Sabak Bernam. Content and thematic analyses were used to develop the sustainability framework, while descriptive and index analyses evaluated sustainability performance. The literature review initially identified 27 criteria and 56 indicators. Following expert validation, these were refined into 20 criteria, 35 indicators, and 53 validated sub-indicators. The developed Malaysian Sustainable Rice Index (MySRI) produced sustainability scores ranging from 50.00% to 90.30%, with an overall score of 80.91%, comprising environmental (80.14%), economic (76.79%), and social (82.84%) dimensions. Pasir Panjang recorded the highest sustainability score (87.90%), while Sekinchan recorded the lowest (67.12%), with both exceeding the minimum sustainability threshold. Despite the favourable overall performance, weak practices were identified in chemical pesticide use, income diversification, and contract record management, highlighting priority areas for policy intervention and agricultural extension. The proposed MySRI provides a validated, context-specific sustainability assessment tool tailored to Malaysian rice cultivation. It integrates international and national sustainability frameworks with locally relevant cultivation practices, regulations, and measurable farm-level indicators. The incorporation of proximity-to-target and categorical normalisation, equal weighting, and additive aggregation enables comprehensive sustainability assessment, benchmarking, and identification of performance gaps. Overall, MySRI serves as a standardised decision-support tool for farmers, policymakers, and agricultural agencies, supporting continuous sustainability monitoring, evidence-based policy development, benchmarking, and targeted interventions to strengthen the sustainability of Malaysia's rice sector.

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LIST OF SYMBOLS

Symbols

ω_i	Weight of Indicator
I_{qc}^{t}	Normalisation of Individual Indicator
X_{qc}^{t}	Raw Value of The Individual Indicator
$A\omega$	Comparison Matrix
CI_c	Composite Indicator
PTT_{ij}	Proximity To Target
C_{jk}	Criteria Score
CAS_{jk}	Criteria Aggregation Score
D_{jI}	Dimension Score
Ij	Index Score

LIST OF ABBREVIATIONS

Abbreviations

AHP	Analytic Hierarchy Process
BAL	Budget Allocation
BOD	Benefit of The Doubt Approach
CVI	Content Validity Index
DPSIR	Driving Force Pressure State Impact Response
FAO	Food And Agriculture Organisation
FiBL	Research Institute of Organic Agriculture
GRI	Global Reporting Initiative
HDI	Human Development Index
IChemE	The Institute of Chemical Engineers
IADA	Integrated Agriculture Development Area
IADA BLS	Integrated Agriculture Development Area Barat Laut Selangor
ILR	Integrative Literature Review
IRRI	International Rice Research Institute
ISP	Index of Social Progress
KADA	Lembaga Kemajuan Pertanian Kemubu
LADA	Land Degradation Assessment in Drylands
LLM	Large Language Model

MADA	Lembaga Kemajuan Pertanian Muda
MADANI	Kemampanan, Kesejahteraan, Daya Cipta, Hormat, Keyakinan, Dan Ihsa
MyGAP	Malaysia Good Agriculture Practice
MASC	Multi-Attribute Assessment of Sustainability of Cropping Systems
MARDI	Malaysia Agriculture Research and Development
MPOCC	Malaysian Palm Oil Certification Council
MSPO	Malaysia Sustainable Palm Oil
MySRI	Malaysian Sustainable Rice Index
NAP	The National Agricultural Policy
NAP	National Agro-Policy
OECD	Organisation For Economic Co-Operation and Development
PO	Public Opinion
POMSI	Palm Oil Mill Sustainable Index
PCA/FA	Principal Component Analysis/ Factor Analysis
PTT	Proximity To Target
RA	Regression Analysis
RSPO	Roundtable Sustainable Palm Oil
RMC	Research Ethics Management
SAFA	Sustainable Assessment for Food and Agriculture
SA	Sensitivity Analysis
Semi-SLR	Semi-Systematic Literature Review

SMART	Sustainability Monitoring and Assessment Routine
SDGs	Sustainable Development Goals
SLR	Systematic Literature Review
SRP	Sustainable Rice Platform
USDA	United State Department of Agriculture
UN	United Nation
UNEP	United Nation Environmental Program
UNCSD	The United Nations Commission for Sustainable Development
UCM	Unobserved Component Models
UKM	Universiti Kebangsaan Malaysia
UiTM	Universiti Teknologi Mara
UPM	Universiti Putra Malaysia
UMS	Universiti Malaysia Sabah
UNDP	United Nations Development Programme

CHAPTER 1
INTRODUCTION

1.1 Research Background

The well-known sustainability concept, introduced globally by Brundtland and her colleagues, stated, “Meeting the needs of the present without compromising the ability of future generations to meet their own needs,” raising concerns about environmental, economic, and social issues (Brundtland et al., 1987). This concept was also absorbed into the agricultural sector, which is concerned about finite resources, food security, climate change, animal welfare, and biodiversity, emphasising the need for sustainable agriculture (De Luca et al., 2018; Karami et al., 2017; Pretty et al., 2010; Steinfeld et al., 2006; Valizadeh et al., 2020). The result of adapting this concept has been reflected in the development of the Sustainable Development Goals (SDGs) and general agricultural frameworks, such as the Sustainability Assessment of Food Agriculture system (SAFA).

In the Malaysian agricultural sector, the concept of sustainable agriculture was adopted through the introduction of the National Agriculture Policy (NAP), the creation of Malaysia Good Agriculture Practices (MyGAP), and sustainable practices derived from issues about sustainability, food security, climate change, and the impact on environmental and human lives (Ehigiamusoe et al., 2024; Tapsir et al., 2019; Solaymani, 2018). While, rice cultivation in Malaysia also adapted these concepts by creating a rice irrigation system (Granary), introduce Rice Check Guideline for cultivation and sustainable cultivation practices derived from concern to the climate change, poverty, living standards, environmental impact, rice self-sufficiency level (SSL) (Firdaus et al., 2020; Harun et al., 2021; Tan et al., 2021; Zakaria & Narna, 2022).

Various interpretations of the concept of sustainability have been proposed by researchers (Ben-Eli, 2018; Glavič & Lukman, 2007; Ruggerio, 2021). Likewise, the concept of sustainable agriculture, which has been developing over the past decades, still faces various challenges (Valizadeh et al., 2020). The challenges include the complex, dynamic behaviour of agriculture system the multidimensional and abstract nature of the sustainable agriculture concept (Maleksaeidi et al., 2015; Renzi et al., 2017; Schoggl et al., 2016). Hayati et al (2010) stated that researching sustainable agriculture needs to answer the question "how can this concept be measured. Several researchers argue that this concept is a social construct (David, 1989; Webster, 1999), not yet made operational (Webster, 1997); precisely measuring this concept is challenging (Ikerd, 1993), and the definition of sustainable depends on the perspective of the researcher (Webster, 1999). Even though this concept is immeasurable precisely, selected parameters and indicators can indicate whether trends are stable, rising, or declining (Pretty, 1995). Thus, there is consensus on the need to use a sustainability indicator to measure its changes (Bell & Morse, 2008; Bockstaller et al., 2015; De Olde et al., 2017; Hayati et al., 2006; Janova et al., 2019; Merli et al., 2018; Pourzand & Bakhshoodeh, 2014)

Several sustainability assessment methodologies exist, such as indicator-based, product-related, and integrated assessments (Ness et al., 2007). Indicators/indices are increasingly recognised as useful tools for policymakers and public communications in providing information on country performance in fields such as environmental, economic, social, or technological development (Singh et al., 2012). These tools are used for their ability to simplify and condense the complexity of the sustainability system into a manageable set of meaningful information (Godfrey & Todd, 2001). It's conceptualising phenomena, assessing the trends, and identifying the hot-spots; indicators simplify, quantify, analyse, and communicate complex information (Warhurst, 2002).

A variety of indicator- and index-based tools have been developed over the past year to measure agricultural sustainability globally and in the Malaysian context (Valizadeh & Hayati, 2020; Marchand et al., 2014; Jamaludin et al., 2018; López-Ridaura et al., 2005). These tools differ from each other in assessment goals, spatial and temporal scopes, and levels of stakeholder engagement (Binder et al., 2010; De Olde et al., 2016; Schader et al., 2014). Thus, several key considerations before developing new sustainability indices at the selected level in the specific agricultural sector. Firstly, site-specific and contextual requirements (Dalsgaard and official, 1997; Riley, 2001; Dumanski & Pieri, 1996), which means indicators/indices should be tailored to a specific location and developed in alignment with the socioeconomic context.

Moreover, the dynamic nature of sustainability, as Hayati et al. (2010) explain, involves indices that evolve as the dimensions and conditions change. Thus, indicators/indices shall be capable of capturing trends and changes rather than providing fixed measurements at a single point in time. This dynamic nature requires continuous monitoring and adaptation of indicators. Furthermore, scale sensitivity (Olembo, 1994). Sustainable agriculture can be evaluated at the farm, regional, and national levels. Thus, the index developer shall consider the scale-level requirements of a different set of indicators. Fourthly, the selection of indicators (Nambiar et al., 2001). The selected indicator should meet the following suitability criteria: a) social and policy relevance, measurable, feasibility of different scales, encompass ecosystem processes, sensitivity to variation, and be accessible to users. Fifthly, aggregation of indicators (Böhringer & Jochem, 2007). Sustainability indices involve multiple indicators; these shall be integrated into a single framework through processes such as weighting, normalisation, and aggregation, all of which are inherently subjective. Further, representative and accessible data (Harger & Meyer, 1996; Kwatra et al., 2020; Morse, 2013; Singh et al., 2012). The index should incorporate all sustainability dimensions and effectively reflect the multidimensional nature of sustainability it is intended to assess. While the data for the indicator included in the index should be readily available within a specified timeframe and relevant at its scale.

In essence, sustainability has been integrated into agriculture at the global and national levels, including Malaysia's rice sector. The multidimensional and complex nature of sustainability was challenging to assess, leading to the use of structured approaches such as indicator/indices models. However, the development of this method requires consideration of how to capture the dynamic and context-specific characteristics of agricultural systems.

1.2 Research Problem Statement

The rice industry in Malaysia was one of the most important agricultural sectors in ensuring the country's food security and rural livelihood. However, still faces persistent challenges, including low productivity, supply instability, and dependence on imported rice (Dorairaj & Govender, 2023; Nodin et al., 2022; Sulwani et al., 2025). Despite government initiatives, such as the National Agriculture Policy (NAP), Malaysia Good Agriculture Practices (MyGAP), and an established granary system, domestic rice production remains challenging to fully meet national demand. This situation affects the rice self-sufficiency level and increases dependence on overseas markets to stabilise domestic supply. Variability in production performance across farming areas and at the farm level further hinders the achievement of consistently higher yields and long-term food security. These issues raise concerns about the long-term sustainability and resilience of Malaysia's rice sector.

The causes of these challenges are multidimensional and interconnected. At the farm level, from an environmental perspective, intensive cultivation practices (Firdaus et al., 2020), water intensive practices (Hanafiah et al., 2019), excessive agrochemical usage (Harun et al., 2022; Mohamed et al., 2016; Terano et al., 2015), SOPs non-adherence (Ali et al., 2021), and open rice residue burning (Ramli et al., 2023) contribute to environmental degradation such as declining soil quality, shortage of fresh water resources, air pollution, ecosystem imbalances, and loss of biodiversity. These environmental impacts can reduce long-term agricultural productivity and increase exposure to climate risks (Nawaz et al., 2022; Simarmata et al., 2021). Furthermore, from an economic perspective, many farmers rely on a single income (Saiful Nathan & Mohd Rosli, 2016), excessive agrochemical use (Harun et al., 2022; Mohamed et al., 2016; Terano et al., 2015), are unaware of specialised accounting (Mustafa et al., 2016), and have weak record-keeping practices (Ali et al., 2021). These resulted from limited skills or knowledge, financial constraints, heavy reliance on agrochemicals, failure to record owned assets, and insufficient time for record-keeping, which contributed to increased operational costs, difficulties in asset valuation, and vulnerability to external economic shocks. Thereby affecting long-term farm productivity and economic resilience. From a social perspective, non-compliance with occupational safety and health standards (Ali et al., 2021). Farmers place less emphasis on safety, health, and welfare components such as hazard risk management, accidents, and the use of PPE because agricultural activities are carried out by their workers. Contributes to pollution and threatens the health of workers and users (Nguyen et al., 2024).

This multidimensionality and interconnectedness are further intensified by the complexity of the sustainability concept, which involves integration among environmental, economic, and social dimensions. These dimensions are interrelated, with changes in one dimension influencing outcomes in others in rice cultivation (Khoo et al., 2025). Thus, assessing sustainability requires dimension integration. However, the complexity of the sustainability concept poses difficulties for practical implementation and operationalisation (Alaoui et al., 2022; Maleksaeidi et al., 2015; Renzi et al., 2017; Schoggl et al., 2016). Influenced by a variety of parameters across the dimensions to be measured, relationships among the dimensions can have positive or negative effects when changes or additions occur among them (Hayati et al., 2010).

Thus, to address the measurement issue, multiple sustainability assessment approaches have been developed, including the widely used indicator/indices tool, which integrates multiple indicators into a single framework and provides simplified interpretation for decision-making (Valizadeh et al., 2020; Singh et al., 2012). Despite its wide use in multiple sectors, including agriculture, it faces multiple problems (Moldan & Dahl, 2007), such as difficulty in interpretation and communication due to the variety of indicators, limited data availability, neglect of integration of dimensions, and inadequate capture of local context, causing stakeholders to lose interest, limited scientific understanding of human-sustainability interaction, poor and inefficient data collection, and context specific to index developer country and neglecting local context. These contribute to overlooked interactions, biased sustainability information, failure to represent local realities, and weakened monitoring and policy evaluation. Furthermore, most agricultural sustainability indicators are incompatible with the contextual and site-specific criteria that vary between sectors, regions, or organisations (Kwatra & Sharma, 2020; Riley, 2001; Valizadeh & Hayati, 2021).

In the Malaysian context, several indices have been developed (Ajidasile, 2015; Jamaludin et al., 2018; Kamaruddin and Abd. Rashid, 2025; Mohamed et al., 2016). However, the existing indices focus on rice cultivation, fail to integrate the main pillar of sustainability (Kamaruddin and Abd. Rashid, 2025; Mohamed et al., 2016), are limited in alignment with the sustainability framework (Ajidasile, 2015; Kamaruddin and Abd. Rashid, 2025; Mohamed et al., 2016) and are limited in integration of index aggregation (Ajidasile, 2015; Kamaruddin and Abd. Rashid, 2025; Mohamed et al., 2016). This results from difficulty integrating the dimension, the use of a generalised framework and indicator, and the complexities of combining indicators with different units and dimensions. Contributed to a sustainability assessment that was incomplete and fragmented, with weak relevance and usefulness, and overrepresented index results. While other sector indices were in a different context for rice (Keyvanfar et al., 2020; Jamaludin et al., 2018; Taylor et al., 1993), it was difficult to integrate their indicators due to different practices, rules, and regulations. Thus, these limitations reduce the effectiveness of existing indices for evaluating sustainability performance and limit their usability as decision-making tools in the Malaysian rice sector.

Therefore, there is a need to develop a new, comprehensive, and context-specific sustainability index focused on Malaysian rice cultivation practices for farm-level assessment. In contrast to existing indices, this study has built a sustainability index that integrates three main pillars of sustainability: environmental, economic, and social, with an aligned sustainability framework (International and local), incorporating locally relevant indicators that reflect the conditions and practices of rice farmers. The proposed index, designed to capture the multidimensional and dynamic nature of sustainability, which is less emphasised by existing indices, allows ease of measurement and practical assessment of rice cultivation practices. This method contributes to improving sustainability performance evaluation and supports informed decision-making, aiming to increase productivity, efficiency in the use of finite resources, and food security in Malaysia.

1.3 Research Objectives

The main objective of this study is to develop a sustainability index for rice farmers' cultivation practices in the Integrated Agricultural Development Area (IADA) of Northwest Selangor. Three specific objectives were created to achieve the index development as stated below:

1. To identify and analyse sustainability criteria and indicator for rice farmers based on environmental, economic, and social dimensions by referring to the current sustainability framework, cultivation practices and guidelines.
2. To validate the identified sustainability criteria based on contextual and practical relevant for rice farmers by referring to the opinion of experts in sustainability and rice cultivation.
3. To assess the sustainability performance of rice farmer cultivation practices in Integrated Agricultural Development Area (IADA) Northwest Selangor and develop a sustainability index using mathematical algorithm.

1.4 Research Question

1) What sustainability criteria and indicator relevant for rice farmers based on environmental, economic, and social dimensions by referring to the current sustainability framework, cultivation practices and guidelines?
2) How can expert opinions be utilised to validate the identified sustainability criteria and indicator contextual and practical relevant for rice farmers cultivation practices?
3) How can the sustainability performance of rice farmer cultivation practices be

assessed and constructed into a sustainability index using mathematical algorithm?

1.5 Research Significance

The creation of this sustainability index is relevant to reducing unsustainable agricultural practices among rice farmers and to ensuring that this tool is continually improved to increase the accuracy of its assessment results, which reflect the cultivation context in Malaysia. In modern agriculture, the emphasis on balancing environmental conservation, economic resilience, and social well-being has become an important element in advancing sustainable agriculture and food security. Therefore, developing a new sustainability index for rice agriculture in Malaysia will provide a competitive advantage by identifying weaknesses, assessing farm-level sustainability performance, and improving practices and indices.

From an academic perspective, index development provides a set of sustainable variables for measuring farms' sustainability performance and the success of applied sustainable practices (Alonso et al., 2024). Furthermore, it provides a methodological procedure for index development that uses variables based on the environmental, economic, and social dimensions of sustainability, thereby contributing to methodological rigour in sustainability assessment (Sulewski & Kłoczko-Gajewska, 2018). In addition, it provides farm-scale metrics grounded in sustainability concepts that can serve as proxies for sustainability goals in benchmarking farms, monitoring progress, and identifying improvements in sustainable agriculture (Storkey et al., 2024). Therefore, the developed index provides a reference for other researchers to use and develop in agricultural sustainability assessment studies at the farm level for various crops.

From a practical perspective, the creation of this index provides an assessment tool to evaluate the sustainability of existing practices among farmers and agricultural agencies. The assessment tool is practical because it can raise awareness and trigger farmers' interest in sustainable farming (Marchand et al., 2014). In addition, provide basis for classifying rice production system based on sustainability performance by helped in designing targeted interventions (Bonny et al., 2010). It even shows the usefulness of the sustainability index as a tool to summarise information based on indicators for overall judgment of farm performance and to provide a rank from best to worst (Gómez-Limón & Sanchez-Fernandez, 2010). Thus, the availability of these tools provides a systematic support role, and technical improvements can be implemented in a more organised, information-based manner.

However, in terms of policy and sustainability, creating an index is relevant because it supports sustainability and aligns with the Sustainable Development Goals and Malaysia's MADANI initiative to improve sustainable agriculture. The index helps frame future agriculture and environmental policy by providing methods for measuring agricultural sustainability and shaping policy design (Jane et al., 2016). In addition, policymakers need relevant and appropriate tools to evaluate current policies, create and improve policy instruments, and assess their performance (Kelly et al., 2018). In addition, sustainability indices serve as pragmatic, easily understandable tools for assessing sustainability, helping develop policies and strategies to achieve inclusive growth and ensure the well-being of farm households (Tiyndel et al., 2025).

Overall, the importance of this study lies in providing one approach to sustainability assessment that structures, contextualises, and can be applied at the farm level, while bridging the gap between the concept of sustainability, its measurability, and rice cultivation practices in Malaysia.

1.6 Research Justification

Rice cultivation continues to play an important role in Malaysia's agricultural sector, contributing to food security, rural development, and socio-economic stability (Abidin et al., 2022; Ishak & Rasiah, 2026; Vaghefi et al., 2016). In Malaysia, rice cultivation is the main source of staple food for Malaysians (Tapsir et al., 2019). A total of 2.05 million metric tons of rice was produced in 2024 (Department of Agriculture Malaysia, 2025). Currently, the rice self-sufficiency level of 52.9% is below the target of 70% by 2025 and 80% by 2030, raising concerns for the country's food security (Khoo & Yunus, 2026). The average national rice production was about 70%, and it still relies on imported rice to support its growing population (Nodin et al., 2023). Dependence on external sources increases vulnerability to global market volatility, geopolitical and climate risk (FAO, 2026; The Washington Post, 2026; Matthews et al., 1997). Recognising the importance of strengthening food resilience in the country, the Ministry of Agriculture and Food Security introduced the National Agrofood Policy 2021-2030 (NAP 2.0) and the latest initiative, namely the PINTAR concept (MAFs, 2021 and 2024). This policy and initiative identify rice as an important sector that needs continuous improvement and expansion in sustainable production and efficient crop management to support the nation's food security objective.

Sustainability issues in agriculture emphasise the need to develop environmentally friendly agricultural technologies and methods that are suitable and useful for farmers and increase food production (Pretty, 2008). The sustainability concept introduced by Brundtland et al. (1987) has become a guide for agricultural development and policy planning, including the introduction of the Sustainable Development Goals (SDGs), which provide basic guidelines for various sectors in each country (Pedersen, 2018). In agriculture, the introduction of the Sustainable Assessment of Food and Agriculture System (SAFA) emphasises that sustainable agriculture development needs to integrate environmental, economic and social dimensions (Scialabba, 2014). In the context of rice cultivation, environmental sustainability includes responsible finite resource practices such as land, water, soil, and air (Li et al., 2020), while economic sustainability emphasises productivity, profitability, and financial resilience (Stuart et al., 2018), and social sustainability focus on farmer well-being, labor rights, capacity development, farming communities (Vinci et al., 2023). Integrating these dimensions is essential for a balanced, holistic understanding of the system, supports the development of a resilient agriculture model, and informs policy and management strategies. The multidimensional importance of designing a resilient rice cultivation system lies in addressing complex and interlinked sustainability challenges (Gharsallah et al., 2021; Gowda & Jayaramaiah, 1998; Jayasiri et al., 2024).

To ensure the sustainability concept becomes a useful criterion for agriculture to bring about change, its characteristics should be literal, system-oriented, quantitative, predictive, stochastic and diagnostic (Hansen, 1996). Therefore, one way to make it useful is through a sustainability assessment approach that encompasses agricultural research, policy evaluation, and farm management. Indicators and indices are a branch of the sustainability assessment approach that is widely recognised for integrating multidimensional sustainability information into a structured, measurable framework that supports systematic evaluation and evidence-based decision-making (Singh et al., 2012). This tool is also useful for policymakers and planners to identify the strengths and weaknesses of agriculture in achieving sustainable agriculture (Abdar et al., 2022). In addition, it summarises complex issues, comparisons, evaluation of results, states performance standards, and indicates project accomplishments (Talukder et al., 2017).

In the context of rice cultivation in Malaysia, integrating the three sustainability dimensions into the index's development is necessary because the concept of sustainability is grounded in the 3-pillar model (Barrier, 2017; Purvis et al., 2019). In addition, it bridges the theoretical framework and practice, provides actionable metrics, and facilitates a balanced understanding of the 3 pillars (Al-Thani & Koc, 2024). Based on these 3 pillars, the index was developed in parallel with international and local frameworks and policies, such as the SDGs and NAP 2.0. Therefore, a sustainability index for rice farmers is necessary to assess environmental impacts from various sources and to evaluate the progress of sustainable development in the rice cultivation system (Roy et al., 2016; Sabiha et al., 2016). Further, help pinpoint sensitive factors, such as farmers' participation in insurance and relative commodity advantage, that require attention to support an increase in sustainable rice production (Rachman et al., 2022). In addition, expanding the concept of assessment methods through indices as introduced by the National Security Council of Malaysia with the National Security Index (IKK) (MKN, 2022). Therefore, the development of this rice farmer sustainability index can support systematic agricultural planning, policy assessment, and long-term food security objectives in Malaysia's agricultural sector.

1.7 Research Scope

This study focuses on the development of the sustainability index and assessment of rice cultivation practices in Malaysia. The foundations of the index and assessment are based on three pillars of sustainability: environmental, economic, and social. An assessment was conducted at the farm level as part of index development, with rice farmers as the primary unit of analysis.

The geographical study was conducted only among rice farmers, covering operations from land preparation to paddy sent to collection centres or mills with granary areas, under the supervision of the Integrated Agriculture Development Area Northwest Selangor, Malaysia (IADA BLS). The findings represent the rice farming system under structured irrigation management and institutional support and do not generalise to non-granary areas. This study also evaluates sustainability through agricultural practices related to land development management, irrigation, agricultural inputs, yield, cost, risk management, legal compliance, farmer well-being, and the health and safety of farmers and workers. The index development is grounded in existing sustainability frameworks and guidelines from international and local sources, validated by experts in rice cultivation and sustainability, and aligned with current practices and regulations in the Malaysian rice cultivation context.

The study's analysis was limited to the development and application of the sustainability index using an adapted mathematical algorithm. The data analysis focused on descriptive approaches to identify and interpret the data and on index computation to evaluate sustainability performance. The inferential statistical, causal modelling and impact assessment analyses were beyond the scope of this study.

1.8 Definition of Terms and Operational

1.8.1 Sustainability

Term: Sustainability refers to the balance of environmental conservation, economic resilience, and social well-being. The main foundations of index development and assessment.

Operational: The measurable environmental, economic, and social performance of rice farmers' cultivation practices is assessed using the MySRI.

1.8.2 Environmental Sustainability

Term: Refer to the conservation and protection of finite resources to reduce environmental degradation and maintain environmental quality.

Operational: Measurable rice cultivation related to zero-burning practices, Water resources, Pre-planting, Timing of harvest, Efficiency of energy use, Waste management and disposal, Planting material, Pest Input, Fertilizer Input, Species Diversity in MySRI.

1.8.3 Economic Sustainability

Term: Refer to the ability of the system to maintain economic viability, financial resilience and long-term stability.

Operational: Measurable economic resilience of rice farmers through Traceability, Stability of Production, Stability of Supply, Liquidity, and Value Creation in MySRI.

1.8.4 Social Sustainability

Term: Refer to social well-being, knowledge, and health and safety of rice farmers in this study.

Operational: Measurable aspects of rice farmers through Quality of Life, Capacity Development, right to use land, Employment condition and Workplace safety in MySRI.

1.8.5 Sustainability Criteria

Term: refers to the main theme of the indicator, with its description for assessing rice farmers' sustainability practices. Criteria are a core element used in the assessment foundation.

Operational: Refer to environmental, economic, and social sustainability components used in MySRI to assess rice farmer sustainability performance through measurable indicators and sub-indicators.

1.8.6 Sustainability Index

Term: Refer to an indicator or index-based assessment tool to evaluate sustainability performance through the integration of multiple sustainability indicators into a single measurement framework.

Operational: Refer to the Malaysian Sustainable Rice Index (MySRI), a multidimensional and context-specific assessment tool to measure rice farmer sustainability practices performance.

1.8.7 Indicator and Sub-Indicator

Term: Measurable variable used to represent and evaluate sustainability status and performance in the index frameworks

Operational: refers to measurable farm-level assessment variables to operationalise sustainability assessment in MySRI.

1.8.8 Normalisation

Term: refers to the approaches used to normalise the different variables; the calculated results give the same meaning to positive and negative effects used in the index calculation

Operational: The use of Proximity to Target (PTT) and a categorical scale to measure heterogeneous units and scale into a comparable sustainability score for index aggregation in MySRI.

1.8.9 Weighting

Term: refers to the approaches used to describe the importance of variables in the index calculation

Operational: The use of an equal weighting procedure to measure balanced dimensions and criteria.

1.8.10 Aggregation

Term: Refers to the process of combining multiple indicators or variables into a single composite value or index score.

Operational: Measuring the aggregated value of multiple indicators from weighted and normalised indicators into composite sustainability scores for environment, economic, social, and overall MySRI score.

1.9 Chapter Summary

This chapter provides the rationale for developing a sustainability index to assess the performance of sustainability practices among rice farmers in Malaysia. Unsustainable practices occur at the farm level in Malaysia, with a limited, comprehensive sustainability framework and index to assess sustainability performance and drive development. The newly developed index provides systematic, comprehensive, and measurable insights for rice farmers, agricultural extension, and policymakers to improve current rice cultivation practices and policies.

1.10 Overview of the Thesis

This section provides a brief overview of all six chapters of this thesis. Chapter One presents the background of the study, the rationale for developing the sustainability index in Malaysia, the study's objective, the research question, the study's significance, and its limitations. In Chapter Two, the concepts of sustainability, sustainable agriculture, the sustainability framework, current issues in agriculture and rice cultivation, sustainability assessment, the sustainability index and procedure, the research gap of the current index, and the theoretical and conceptual framework of the study.

Chapter three presented the methodology of index development. The use of mixed methods approaches in index development. The development was divided into objectives, which laid the foundation for index assessment and for calculating the index from the collected data. Furthermore, a detailed explanation of the procedure and the reasons for applying the approaches to index development. Chapter four presented the findings for each objective, proposed sustainability criteria for rice farmers in Malaysia, and then presented the finalised sustainability criteria and the index assessment findings to rice farmers. The results are presented in table form, describing the detailed proposed and finalised criteria, a bar chart, and a numerical and rating scale for the rice farmer assessment.

In chapter five, the discussion on the findings of each objective is presented. The proposed sustainability criteria, finalised sustainability criteria and the farmer index assessment are used to describe the pattern identified in the analysis. The discussion also presents the development of the new index and its comparison with past indices, with a focus on agriculture and rice cultivation. The final chapter presents an overview of the study, its contributions, implications, limitations, and suggestions for future improvements to the index development and findings.

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CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter reviews the literature on developing a sustainability index for rice cultivation practices in Malaysia. The structure of the review starts with (a) the foundation of sustainability and sustainable agriculture, (b) the sustainability assessment and index construction, and (c) the empirical and methodological gaps applied in agriculture and rice cultivation in Malaysia. Further, this chapter synthesises and evaluates prior studies, demonstrating the limitations of existing frameworks and indices for capturing the multidimensional, context-specific, and farm-level nature of sustainability in rice cultivation. Thus, the synthesis provides the theoretical and methodological justification for developing a new sustainability index focusing on Malaysian rice farmers.

2.2 Sustainability Concept

The concept of sustainability was developed many years ago to address concerns about the depletion of finite natural resources (Thiele, 2016), leading to a multidimensional framework that combines environmental integrity, economic resilience, and social well-being (Thiele, 2016). However, at the outset of sustainability's establishment as a focus on environmental conservation, past researchers emphasised the interdependence among the environmental, economic, and social dimensions of sustainability (Allen et al., 2018; Ben-Eli, 2018; Carter & Rogers, 2008; Shrivastava, 1995). The definition often cited by the Brundtland Commission of sustainability is "Meeting the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland et al., 1987), thereby embedding intergenerational responsibility at its core.

Despite increasing adoption, sustainability remains a complex and contested concept (Mebratu, 1998). Sustainability is multidimensional, which makes it difficult to operationalise, for example, through measurable indicators. Various researchers have stated that this concept poses difficulties for translation into an outcome or variable, because improving just one dimension may result in trade-offs in others (Moldan &

Dahl, 2007; Fiksel, 2006; Wells, 2012). The ambiguity of the sustainability concept affects the outcomes of sustainability assessments, which require that the assessment method be chosen transparently and that the underlying assumptions be stated.

Therefore, to address these challenges, the three-pillar sustainability model that underpins the sustainability assessment framework is environmental, economic, and social sustainability (Barrier, 2017; Purvis et al., 2019), as shown in Figure 2.1. Although this model does not address conceptual sustainability, it provides a basic framework for translating sustainability into operational indicators, particularly in the agricultural sector.

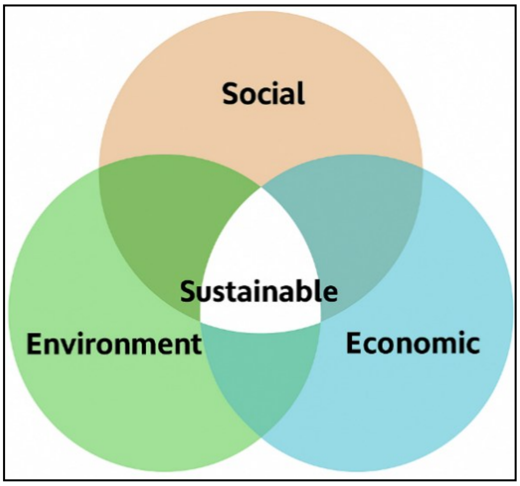


Figure 2.1 Three Intersecting Sustainability Pillars

2.3 Sustainable Agriculture and Rice Cultivation

Agriculture is a significant sector in every country in contributing to the food supply. Therefore, the concept of sustainable agriculture stems from the Brundtland report of 1986 (Tait & Morris, 2000). Sustainable agriculture shares the same basis as the three intersecting sustainability pillars, but adds it only at the midpoint of the intersection, as shown in Figure 2.2 (Bathaei & Štreimikienė, 2023). There is a definition specifically created for the term “sustainable agriculture”, including management activities that work with natural processes to maintain, reduce negative impacts and problems, support the resilience of agricultural systems, and sustain production to meet the needs and nourishment of all humans (MacRae et al., 1989). “For a farm to be sustainable, it must produce adequate amounts of high-quality food, protect its resources, and be both environmentally safe and profitable” (Reganold et al., 1990).

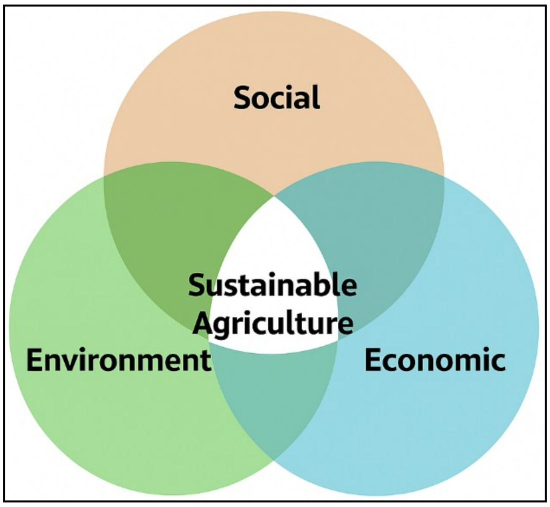


Figure 2.2 Three Intersecting Sustainable Agriculture Pillars

Previous studies have stated that sustainable agriculture extends beyond productivity maximisation (Kyle et al., 2023; Pretty, 2008). Covering resource conservation, economic resilience, social well-being, resilience to natural disasters, and market shocks, as shown in Table 2.1, are issues facing agriculture. Likewise, in the Malaysian context, sustainable agriculture is important for food security, environmental protection, and socio-economic development. Agriculture is also one of the sectors on which the country relies for the well-being of rural communities, export income, and food supply stability (Khorramnia et al., 2014; Wahid et al., 2024). There are also environmental issues facing Malaysian agriculture, such as resource competition, inefficient traditional irrigation, high water use, environmental pollution and degradation, and climate change impact (Ahmad et al., 2024; Alam et al., 2020; Damanhuri et al., 2024; Ilahi et al., 2022; Ishak et al., 2022; Murad et al., 2009; Othman et al., 2010; Talib et al., 2024; Tiraieyari et al., 2014).

Table 2.1
Summary of Social, Economic, and Environmental Issues

Dimension	Issue	References
Social	High stress, mental health challenges, poor work-life balance	Brennan et al., 2020; Doetzer et al., 2025; Janker et al., 2019
	Low wages, hazardous work, gender disparities, seasonal employment, and health risks	Adıbelli et al., 2022; Kumari et al., 2025; Santos et al., 2025
	Low stakeholder involvement, lack of governance, and weak participatory decision-making	Banda et al., 2025; Parzonko et al., 2025; Young et al., 2022
	Low social networks, low organisational participation, exclusion	Banda et al., 2025; Liao et al., 2025; Young et al., 2022
	An ageing population, low participation by younger generations, and older farmers.	Brennan et al., 2020; Calafat-Marzal et al., 2016; Jiabin et al.,

		2019
	Land conflict, urbanisation, and loss of agricultural land	Kalisz et al., 2023; Rani, 2019
Economic	Rising input cost	Fuglie et al., 2012; Mishra and Mishra, 2025
	Climate change raises input costs.	Babu, 2024; Kumar et al., 2025
	Market access and monopolies	Galanakis et al, 2025; Ndhlovu, 2025
	Financial support	Rayhan et al., 2024; Zuo, 2023
Environmental	Inefficient traditional agriculture	Ali et al.,2025; Murali et al., 2024; Şimşek, 2025;
	Agriculture contribute pollution	Abbasi et al., 2013; McDowell et al., 2020
	Major GHG source	Dmuchowski et al., 2024; Kamyab et al., 2024

For economic sustainability issues, such as low productivity, high costs, institutional barriers for farmers, and technology adoption challenges (Azri et al., 2025; Chalil et al., 2024; Kasim et al., 2023; Martin et al., 2015; Rana et al., 2025). Next, social sustainability issues include labour conditions, workplace safety, food security, and cultural factors that hinder sustainability (Nawik et al., 2015; Nazuri et al., 2022; Tey et al., 2014; Wong et al., 2021). In Malaysia, rice (scientifically known as Oryza sativa L.) is the predominant staple crop, providing sustenance for over 50% of the global population. Additionally, it serves as a vital economic resource for most individuals residing in Asia and Africa (Nawaz et al., 2022). By 2025, global rice production and consumption are expected to reach over 510 million metric tons (Durand-Morat & Bairagi, 2021). Rice cultivation in Malaysia is a key driver of food security and sustainability. However, the rice industry faced environmental sustainability issues such as soil degradation, high water usage, greenhouse gas emissions, loss of biodiversity, and weak extension (Abdullah et al., 1997; Bakar et al., 2025; Bala et al., 2014; Ilahi et al., 2022; Kamarudin et al., 2016).

On the economic sustainability issue, the high cost of production, climate uncertainty affects income, technology adoption barriers, climate change reduces income, and market policies affect income (Doni et al., 2017; Dordkeshan et al., 2017; Firdaus et al., 2014; Vaghefi et al., 2016; Muazu et al., 2016; Nordin et al., 2023). Moreover, on social sustainability issues such as low living standards and health impacts (Ali et al., 2018; Hasan-Basri et al., 2024; Sharaai et al., 2022). Most of these matters start at the farm level, where management decisions affect higher levels. Therefore, these characteristics indicate the need for a sustainability assessment that evaluates the impact of cultivation practices on environmental conditions and the socio-economic realities at the farm level.

2.4 Sustainability Criteria or Framework

Across each sustainability dimension or pillar, the world has established initiatives to reduce and eliminate these issues. International summits held by the United Nations, such as the Earth Summit in Geneva, Rio de Janeiro, Kyoto, New York, and France. In addition, sustainability criteria have been developed during the summits and by various organisations. Sustainability criteria were created to ensure long-term sustainability and stable investments (Pavlovskaia, 2014). Concept sustainability served as the foundation for developing sustainability criteria. One of the definitions of sustainability criteria is "criteria used to assess risk and opportunity arising from social, economic, and environmental sustainability dimensions (Zink, 2005). Sustainability criteria can be expressed in qualitative or quantitative terms (Goldschmidt et al., 2013). It also helps to identify sustainability policy approaches, trends, and effects (Spangenberg, 2017). In addition, it is included in the legal framework and in voluntary sustainability standards created to serve specific purposes (Pavlovskaia, 2014). Table 2.2 shows the diversity of sustainability frameworks and criteria developed.

Table 2.2
Summary of Sustainability Criteria and Framework

Sustainability criteria/framework	**References**
UN Agenda 21 (1991)	Spangenberg et al., 2002
UNEP Green Economy Initiative (GEI)	Georgeson et al., 2017
The pressure-state-response framework	Singh et al., 2012
The Driving Force Pressure State Impact Response (DPSIR) model	Singh et al., 2012
Global Reporting Initiative (GRI) Framework	Singh et al., 2012
The United Nations Commission for Sustainable Development (UNCSD)	Singh et al., 2012
The Institute of Chemical Engineers (IChemE) Sustainability Metrics.	Singh et al., 2012

There are also frameworks for agriculture to enhance sustainability, such as the Sustainability Assessment of Food Agriculture (SAFA) system, created by the Food and Agriculture Organisation (FAO), to assess the environmental, economic, and social impacts of agricultural management (Scialabba, 2014). Next, the Response Inducing Sustainability Evaluation was developed in Switzerland to assess the people, plants, and profits of farm sustainability operations (Häni et al., 2003). Then, the Multi-attribute Assessment of Sustainability of Cropping Systems (MASC) was used to assess sustainability at the land level (Sadok et al., 2009). The Food and Agriculture Organisation (FAO) also developed another framework to assess land degradation, namely the Land Degradation Assessment in Drylands (LADA) (Nachtergaele et al., 2010). Next, FiBL (Research Institute of Organic Agriculture) has developed the Sustainability Monitoring and Assessment Routine (SMART) to assess farmers' sustainability levels and demonstrate credibility and transparency (Landert et al., 2020). Furthermore, the United Nations' current sustainability framework is the Sustainable Development Goals (SDGs), as shown in Figure 2.3 (Pedersen, 2018).

Figure 2.3 Sustainable Development Goals (SDGs)

In Malaysia, there are two sustainability frameworks or guidelines: Malaysia Sustainable Palm Oil (MSPO), which focuses on the production of crude palm oil from upstream to downstream. Whereas Malaysian Good Agriculture Practices (MyGAP) focuses on general agricultural production guidelines divided into three categories: crops, livestock, and fisheries. The variety of agricultural frameworks, including those in Malaysia, varies in content, making them unsuitable for direct use as a basis for assessment or measurement. This is because the sustainability framework usually focuses on a single crop production system, making it difficult to use broadly (Angevin et al., 2017). In addition, the general framework is distinctive in its identification, development, and evaluation of agricultural production systems, techniques, and policies that are not tailored to a single crop (Van Cauwenbergh et al., 2007). In addition, the framework or criteria for assessing agricultural sustainability must be flexible enough to adapt to agricultural landscapes and changing environmental conditions (Eichler et al., 2018). Since there are limited sustainability frameworks, criteria, or guidelines for rice cultivation at the farm level in Malaysia, there is a need to develop one as a basis for sustainability assessment.

2.5 Sustainability Assessment

Based on sustainability criteria, various sustainability assessment practices have been developed to support sustainable development. Sustainability assessment is defined as "any process, activity, action that influences decision-making strategy" (Bond et al., 2012). The purpose of sustainability assessment serves as a) information generation, operationalisation, and forum; b) social learning; and c) structuring complexity (Waas et al., 2014). There are 3 types of sustainability assessment tools introduced: (1) indicators and indices, (2) product assessment tools, and (3) integrated assessment, shown in Figure 2.4 (Ness et al., 2007).

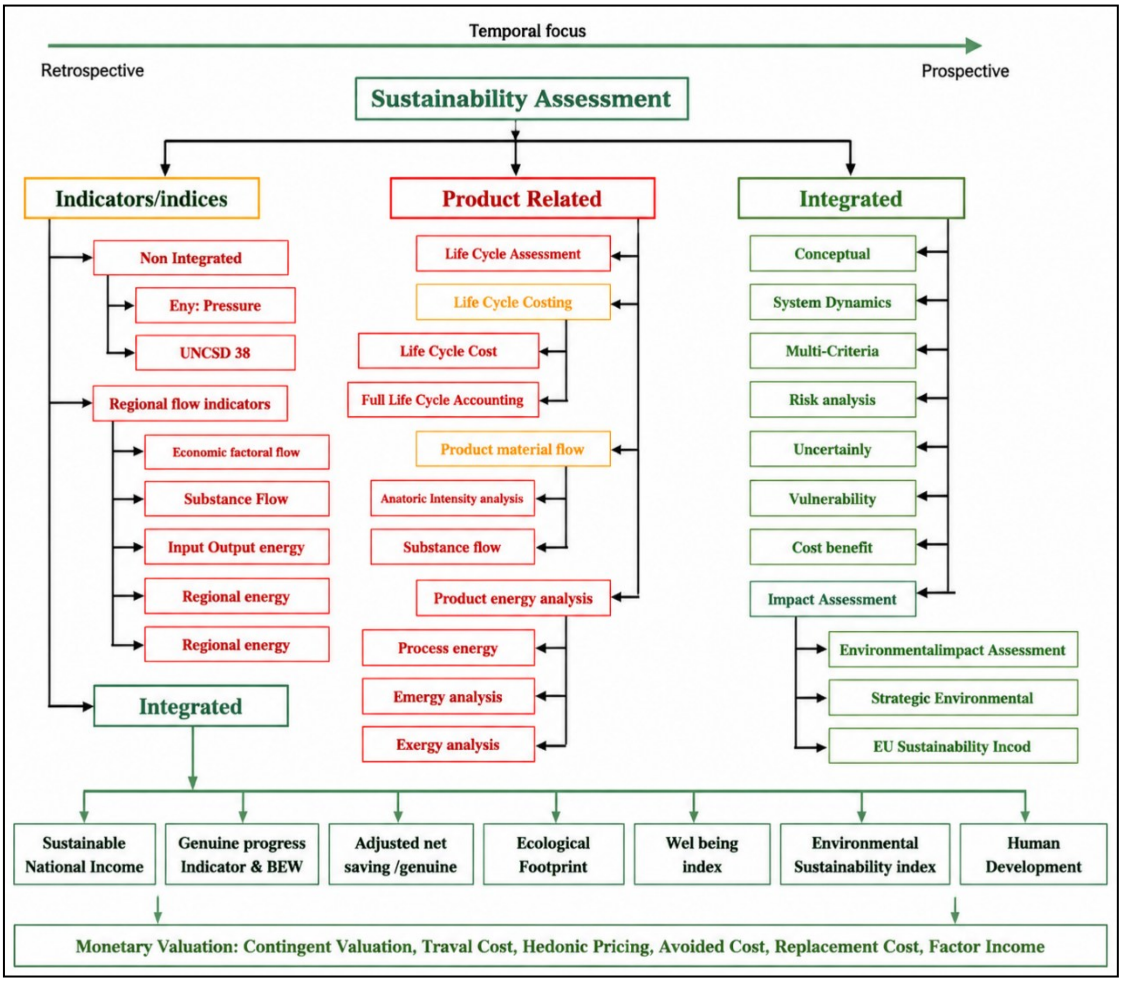


Figure 2.4 Type of Sustainability Assessment Tools Framework

This study focuses on indicator-based approaches, which are among the most widely applied in agricultural assessment (Chopin et al., 2021). Gomez & Sanchez (2010) stated that indicators or indices provide a method for summarising indicator-based information into an overall assessment of farm performance and for ranking farms based on specified characteristics. In addition, common tools for assessing agricultural sustainability capture complexity and multifunctionality (Wiget et al., 2020). However, there are challenges in using these tools, such as data comparability, aggregation, stakeholder involvement, and interpretation.

2.5.1 Sustainability Index

Addressing the challenge indicators outlined in section 2.5, a sustainability index that combines multiple indicators into a single composite measure is appropriate. In general, an indicator is a parameter that provides information about and describes the state of a phenomenon (Delzeit et al., 2009). An “indicator” is a variable that describes one characteristic of the state of a system, usually through observed or estimated data. Some indicators may provide information on the system's position relative to sustainability boundaries or goals (“distance-to-target” indicators). When many indicators are used, they are either presented in a framework of categories or aggregated into an index. An “index” is a quantitative aggregation of many indicators and can provide a simplified, coherent, multidimensional view of a system (Mayer, 2008). Various sustainable indices have been created worldwide, as shown in Table 2.3.

Table 2.3
Summary of Worldwide Sustainability Index

No	Sustainability criteria/framework	References
1	Summary Innovation Index	Singh et al., 2012
2	Technology Achievement Index	
3	Human Development Index	
4	Index of sustainable and economic welfare	
5	Internal Market Index	
6	Eco-system-based Indices	
7	Environmental Vulnerability Index	
8	Composite Sustainability Performance Index	
9	Composite sustainable development index	
10	Life Cycle Index	
11	Urban Sustainability Index	
12	Environmental Quality Index	

Most sustainability indices are used to compare performance across assessed issues, such as impact and footprint, based on environmental, economic, and social aspects (Mori & Christodoulou, 2012). In agriculture, this tool is used to monitor and evaluate agricultural practices and to inform decision-making by providing information on criteria that are difficult to access (Latruffe et al., 2016). In addition, it supports the sustainable development of farms by assessing their sustainability performance using indicator-based tools (De Olde et al., 2016). However, sustainability indices are not neutral measurement tools or the best tools to compare; they also have limitations. Several past studies highlight the limitations of the tools, such as a lack of consistency and methodological rigour (Babcicky, 2013), the selection of weighting and aggregation methods (Gan et al., 2017), and the use of simple indicators for complex systems (Bell & Christodoulou, 2012). Therefore, this limitation needs to be considered in making the index to ensure robustness and credibility.

2.5.2 Sustainability Index Development

Each sustainability index developed from the literature has different objectives, scopes, fields, and structures for assessing sustainability. These indices differ primarily in the indicators and calculations used to obtain their index values (Ziemba et al., 2022). In addition, the index models do not all follow the order of creation, but the basic principles of creation are still applied. Among the index development models that show index development are Ibáñez-Forés et al. (2014), Illahi & Mir (2020), Jamaludin et al. (2018), and Juwana et al. (2012). A general procedure is introduced in the creation process, from developing a theoretical framework to presenting the results (Joint Research Centre, 2008; Ziemba et al., 2022). Summary of index development is shown in Table 2.4.

Table 2.4
Summary of Model Procedure

Model	OECD General Model	Energy General Model
References	Joint Research Centre, 2008	Ziemba et al., 2022
Procedure	1. Theoretical development 2. Variable selection 3. Missing data 4. Multivariate analysis 5. Normalisation 6. Weighting and aggregation 7. Robustness and sensitivity	1. Setting Objective 2. Indicator selection 3. Value of indicator 4. Normalisation 5. Weightage 6. Aggregation 7. Sensitivity analysis

8. Presentation	8. Results

2.5.2.1 Theoretical Development

In this initial procedure, the theoretical framework needs to define phenomena and state the objectives to be measured regarding sub-components and indicators. This ensures transparency and the production of credible indicators. Therefore, define the concepts and subgroups and identify the criteria for forming the index (Joint Research Centre, 2008). In this phase, various methods are used to develop the theoretical framework, particularly sustainability criteria, drawing on past literature. Table 2.5 shows the different approaches to criteria development.

Table 2.5
Summary of Framework or Criteria Development Approach

No	Name of framework/criteria	Approach	References
1	Egyptian infrastructure and Service facility framework	Interview and Questionnaire	Elbarkouky et al., 2012
2	S-ERP framework	Review and interview	Chofreh et al., 2017, 2018
3	Integrated assessment of urban transportation sustainability	Structured literature review	Gutiérrez et al., 2022
4	Sustainability framework for higher education institutions (HEIs)	Systematic review and interview	Umar, 2022.
5	Sustainable e-learning framework for higher education in Malaysia	Comprehensive literature review, Focus group discussion (FGD), and Interview	Sofiadin, 2021
6	Sustainable heritage-led urban regeneration planning framework	Literature review, Interview, and Questionnaire	Dogruyol et al., 2018
7	Sustainability Scale-Up Framework (SSF) for businesses	Literature review and Interview	Panigrahi et al., 2025

2.5.2.2 Indicator Selection or Variable

The index is measured using quantitative and qualitative indicators (Ziemba et al., 2022). These indicators are grouped into components and further divided into sub-indicators (Juwana et al., 2012). Indicators and sub-indicators are organized hierarchically, as shown in Figure 2.5 (De Olde et al., 2016).

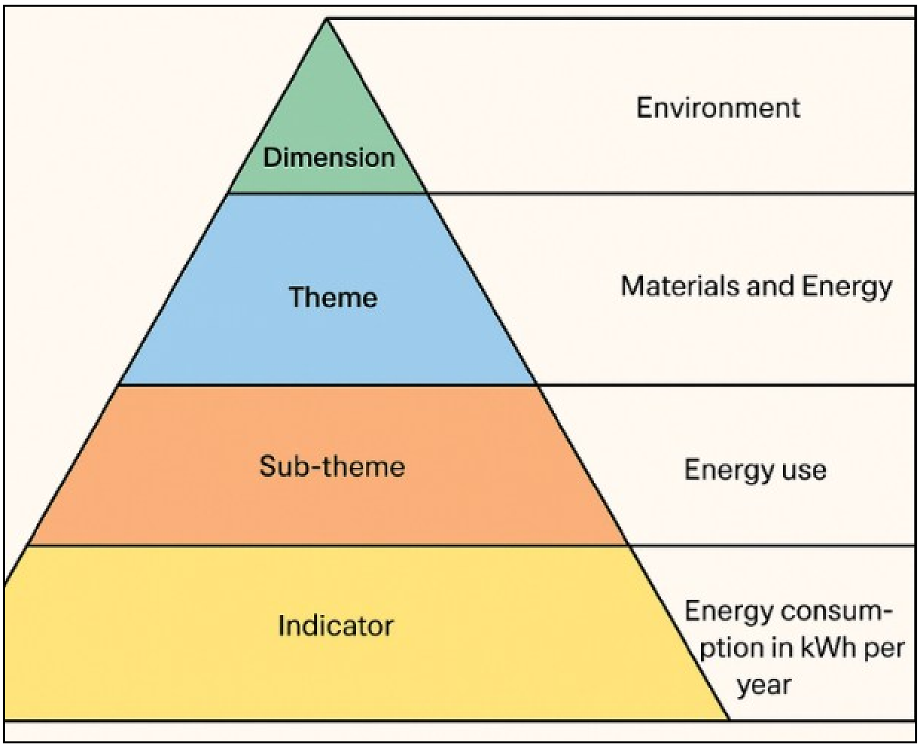


Figure 2.5 Hierarchy of Sustainability Criteria, Indicators and Sub-Indicators

There are seven features to consider when selecting indicators for sustainability assessment, as outlined by Liverman et al. (1988). The features are a) responsive to time volatility, b) responsive to space and group variability, c) predictability, reference values availability, d) unbiased, e) data transformation and f) complexity. Next, the indicator must align with the sustainability concept, clearly represent individual domains, be measurable, be process-oriented, and align with political goals (Böhringer & Jochem, 2007). Where is the source of information to measure the indicator collected based on a) primary data, b) secondary data, c) simulations, and d) opinions of experts (Ibáñez-Forés et al., 2014).

2.5.2.3 Data Normalisation

Each indicator in a data set often has a different unit of measurement, which requires normalisation (Joint Research Centre, 2008). To ensure that indicators with different units are translated into a common scale, it is necessary to normalise the indicator values (Diaz-Balteiro et al., 2017). Several normalisation techniques have been introduced (Joint Research Centre, 2008), as shown in Table 2.6.

Table 2.6
Summary of Normalisation Techniques and Formula

No	Method name	Formula
1	Min-Max	$I_{qc}^{t} = \frac{X_{qc}^{t} - X_{qc=\bar{c}}^{t}}{\sigma_{qc=\bar{c}}^{t}}$
2	Distance to a reference	$I_{qc}^{t} = \frac{X_{qc}^{t}}{X_{qc=\bar{c}}^{t_0}}$ or $I_{qc}^{t} = \frac{X_{qc}^{t} - X_{qc=\bar{c}}^{t_0}}{X_{qc=\bar{c}}^{t_0}}$
3	Ranking	$I_{qc}^{t} = Rank\left(x_{qc}^{t}\right)$
4	Z-scores or Standardisation	$I_{qc}^{t} = \frac{X_{qc}^{t} - X_{qc=\bar{c}}^{t}}{\sigma_{qc=\bar{c}}^{t}}$

2.5.2.4 Weighting

State the weight indicator or component to ensure the relative importance of each (Ziemba et al., 2022). The indicator weight priorities influence index values and may vary (Ibáñez-Forés et al., 2014; Joint Research Centre, 2008). There are eight types of weighting methods, such as Equal weighting, PCA/FA, Benefit of the doubt approach (BOD), Regression analysis (RA), Unobserved component models (UCM), Budget allocation (BAL), Public opinion (PO) and Analytic hierarchy process (AHP) (Gan et al., 2017). Table 2.7 summarises the common methods of indicator weighting.

Table 2.7
Summary of Weighting Method and Formula

No	Method name	Type	Formula
1	Equal weighting	Equal	$\omega_i = \omega, \quad i = 1, \ldots, m$ ω_i is the weight of the i^{th} indicator, and ω is a constant used as the weight for all the indicators
2	PCA/FA	Statistic	$\omega_i = r_j\left(l_{ij}^2 / E_j\right)$ $i = 1, \ldots, m; \quad j = 1, \ldots, n$ r_j is the proportion of the explained variance of factor j in the data set, l_{ij} E_{j} *is* the variance explained by factor j

3	Benefit of the doubt approach (BOD)	Statistic	$\omega_c = \arg \omega_{c,i} \dfrac{\sum_{i=1}^{m} \omega_{c,i} y_{c,i}}{\max\limits_{y_j \in \{\text{studied units}\}} \left(\sum_{i=1}^{m} \omega_{c,i} x_{j,i}\right)}$ s.t. $\sum_{i=1}^{m} \omega_{c,i} x_{c,i} \leq 1, \quad \omega_{c,i} \geq 0$ $\forall i = 1, \dots, m; \quad \forall j = 1, \dots, n$ $\boldsymbol{\omega_c}$ is the weight vector f unit c, $\omega_{c,i}$ the weight of the i^{th} indicator of unic c, and $I_{j,i}$ the normalised score of the i^{th} indicator of the j^{th} unit
4	Regression analysis (RA)	Statistic	$\omega_i = \beta_j, \quad i = 1, \dots, m$ β_j is the regression coefficient of the i^{th} indicator
5	Unobserved component models (UCM)	Statistic	$\omega_i = \dfrac{\delta_t^2}{1 + \sum_{i=1}^{m} \delta_t^2}$ $i = 1, \dots, m$ δi is the variance of the i^{th} indicator
6	Budget allocation (BAL)	Public or expert opinion	Not available
7	Public opinion (PO)	Public or expert opinion	Not available
8	Analytic hierarchy process (AHP)	Public or expert opinion	$A\omega = \lambda\omega$ A is the comparison matrix, λ is the largest eigenvalue of A, and $\boldsymbol{\omega}$ **is** the weight vector as well as the eigenvector corresponding to λ

2.5.2.5 Aggregation

Aggregating involves specifying weight indicators or components to ensure the relative importance of each other (Ziemba et al., 2022). Most index developers will use a sub-indicator, then an indicator, a component, and the final dimension to get the overall index value. Various methods are used to aggregate indicators according to their purpose and scope (Singh et al., 2012). Table 2.8 shows 2 types of general aggregation formulas used in index making (Joint Research Centre, 2008; Ziemba et al., 2022).

Table 2.8
Summary of The Aggregation Method

No	Method name	Formula
1	Additive aggregation	$CI_c \sum_{q-1}^{Q} Rank_q c$ for c = 1,..,M,
2	PCA/FA	$In = \prod_{j=1}^{n} In_k\, wj$

2.5.2.6 Uncertainty and Sensitivity

Creating an index involves many subjective choices, such as the data used, how to handle missing data, and the weight to apply, which form the backbone of the index model (Joint Research Centre, 2008). Sensitivity analysis (SA) is defined as the process of taking an X-ray of the index model (Kennedy, 2003). This method aims to ensure that the index is reliable and stable, increase transparency, and pinpoint the impact of assumptions. Sensitivity analysis also identifies indicators that improve the results of sustainability assessment (Mayer, 2008). This analysis can be done at any stage of index development (Ziemba et al., 2022).

2.5.2.7 Presentation of Result

Result interpretation is the last stage in sustainability assessment. The index calculation results will be presented as a numerical value describing a single action or as a ranking (Ziemba et al., 2022). Some are presented in bar charts, web charts, and rating scales (Bonny & Vijayaragavan, 2001; Bonny et al., 2010; Sabiha et al., 2016; Castoldi & Bechini, 2010; Mohamed et al., 2016). Some indices interpret the results separately for the indicator, component, criteria, and overall index (Juwana et al., 2012).

2.6 Bibliometric Analysis

A review of previous studies on sustainability indices in agriculture used bibliometric methods (Donthu et al., 2021) to provide an overview of the development of these indices. Analysis was conducted using LENS.ORG, an open-source database. This platform aggregates data from various primary sources, combining important indicators from the original datasets to demonstrate transparency and interaction with other datasets (Mohd Ishar et al., 2024). In fact, this strategy ensures that data are reliable and easily obtainable (Van Eck & Waltman, 2010).

2.6.1 Methods

The search was conducted using the LENS.ORG database on its website for two intended purposes: a global and a Malaysian perspective. The search string was applied to the global view (Title: (Sustainability AND (indices AND (or AND (index AND (in AND agriculture))))) OR (Abstract: (Sustainability AND (indices AND (or AND (index AND (in AND agriculture))))) OR (Keyword: (Sustainability AND (indices AND (or AND (index AND (in AND agriculture))))) OR Field of Study: (Sustainability AND (indices AND (or AND (index AND (in AND agriculture) resulting in 1,729 scholarly works, 13 cited by patents, and 1016 cited by scholarly starting from year 1980 to 2025. The LENS.ORG link was https://link.lens.org/JyIqD19neSi. While for Malaysia perspective the search string was (Title: (Sustainability AND (index AND (for AND (agriculture AND (in AND Mal aysia))))) OR (Abstract: (Sustainability AND (index AND (for AND (agricultur e AND (in AND Malaysia))))) OR (Keyword: (Sustainability AND (index AND (for AND (agriculture AND (in AND Malaysia))))) OR DOI: (Sustainability AN D (index AND (for AND (agriculture AND (in AND Malaysia) resulting in 157 scholarly works, 1 cited by patents, and 64 cited by scholarly starting from the year 1980 to 2025. The LENS.ORG link was https://link.lens.org/m2rRY8wsTWe. The analysis was conducted automatically by LENS.ORG and provided the current distribution and characteristics of published scholarly work, the country of publication, and the index's field of study.

2.6.2 Past Global Literature Distribution and Characteristics

The development of literature publications on the global stage shows an increasing trend in the use and development index, as shown in Figure 2.6. Published works began in the early 1990s and gradually increased until 2017. In 2018, the increase accelerated sharply until 2025, during which more than 400 studies were published on the index. This shows that the development index is growing.

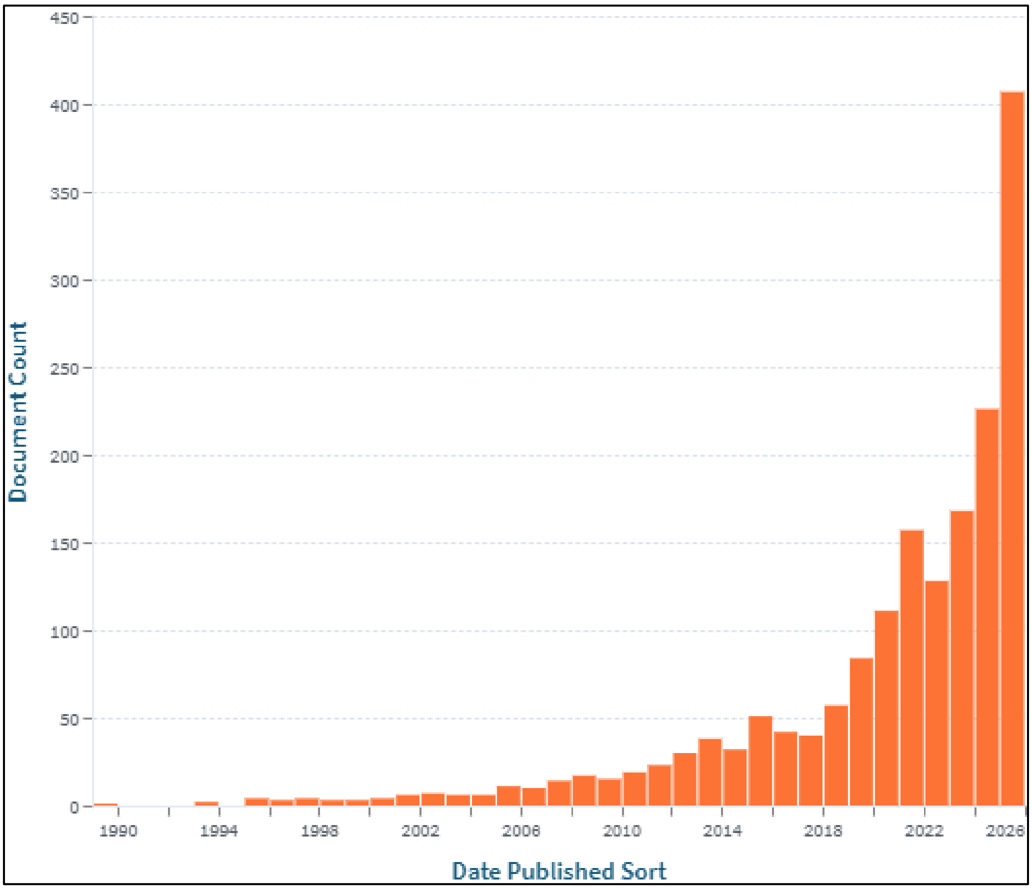


Figure 2.6 Number of Publications Per Year

Figure 2.7 Scholar Work Distribution Based on Country

The distribution of scholarly work by country, as shown in Figure 2.7, indicates that China produces the most indices with 206, followed by the United States of America with 106. This word cloud shows that the G20 countries, which are mostly developed, have the highest volume of published work. However, Malaysia has 8 publications on this index, which is one of its contributors.

2.6.2.1 Selected Global Index

Several past studies on index development have been selected for an overview and thematic descriptions. The literature studies were selected because they are relevant to the context of this study, as shown in Table 2.9, global index matrix.

Table 2.9
Global Index Matrix

Article (Author/ Year)	Country	Crop Type	Assessment level	Theoretical Framework	Selection Variable (Dimensions)	Normalization Method	Weighting Method	Aggregation Method	Robustness & Sensitivity
Defiesta & Rapera (2020).	Philippines	Rice, watermelon, sugarcane, and vegetables	Farm/ Household	Current: Sustainable Livelihoods (SL)	5 Capitals (Human, Physical, Financial, Info, Diversity)	Vector normalization	Analytic Hierarchy Process (AHP)	Weighted linear aggregation	Not mentioned explicitly
Bonny & Vijayaragavan (2001).	India	Traditional Rice	Farm	Not mentioned explicitly	Production practices (Plant protection, Soil health)	Min-Max formula (0–100 scale)	Expert judgment	Cumulative scoring	Not mentioned explicitly
Bonny et al. (2010).	India	Rice production systems	Field/Community	Current: Agro-ecosystem functional properties	Economic, Ecological, Social	Deviation from average/optimal (-1, 0, 1)	Principal Component Analysis (PCA)	Weighted average of summated scores	Factor-analysed communality scores
Talukder et al. (2017).	Bangladesh	Shrimp, Rice, Vegetables	Farm	Not mentioned explicitly	Productivity, Stability, Efficiency, Durability, Compatibility, Equity	Compared 5 methods; prefers Proportionate	Equal Weighting and Budget Allocation	Hybrid (Arithmetic & Geometric)	Correlation to assess the impact of rules

Valizadeh & Hayati (2021).	Iran	Wheat	Farm	Not mentioned explicitly	Equity/Well-being, Durability, Stability/ Compatibility, Productivity/ Efficiency	Proportionate normalization	McGranahan method (Correlation matrix)	Factor Analysis (CFA) structures	Cross-Validation Method (CVM) and ISA
Terano et al. (2015).	Malaysia	Paddy	Farm/Field	Malaysian Rice check guidelines	30 Farming practices (Land prep, Seed, Fertiliser, Pests)	Min-Max formula (0–100 scale)	Not mentioned explicitly	Sum of indexed scores	Not mentioned explicitly
Castoldi & Bechini (2010).	Italy	Maize, Rice, Wheat, Permanent Meadows	Field	Agro-ecological indicators	Economy, Nutrient, Energy, Pesticide, Soil	Non-linear sustainability functions	Budget allocation and equal weight	Two-step additive approach	Not mentioned explicitly
Sabiha et al. (2016).	Bangladesh	HYV Rice	Farm	Multiple sustainability frameworks	Means-based, Effect-based, Perception-based	Optimal range scoring (MBF/LBF)	Machine-specific weights in SSF	Statistical additive aggregation	Not mentioned explicitly
Roy et al. (2014).	Bangladesh	Boro, Aman, and Aus Rice	Farm	Multiple sustainability frameworks	Social, Environmental, Economic, Political	Max-Min and Standardisation	Factor Analysis (FA)	Linear (within) and Geometric (across) dimensions	The internal consistency of CI
Roy et al. (2016).	Bangladesh	Irrigated, Rain-fed, Flood/Saline Rice	Farm	National policies	Economic, Environmental, Social	Max-Min normalisation	Factor Analysis (FA)	Linear (within) and Geometric (across) dimensions	Internal consistency and robustness checking

Mohamed et al. (2016).	Malaysia	Paddy	Farm	Malaysian Rice check guidelines	Seeding, Fertiliser, Weed control, Pest control	Min-Max formula (0–100 scale)	Independent weights based on influence	Sum of sustainability scores	Not mentioned explicitly

Based on Table 2.9, past studies show that the assessment and development of the index are carried out using a structural approach to measure agricultural sustainability, from conceptual definition to mathematical validation. Themes are derived from these studies, such as the multidimensional sustainability framework, to provide a picture of the complexity of agroecosystems that rejects one-dimensional assessments (1,2,3,4). Some focus on only one dimension within the scope of the studies and are not based on the sustainability concept, such as (Bonny et al., 2010; Defiesta & Rapera, 2020; Roy et al., 2014; Roy et al., 2015; Sabiha et al., 2016; Talukder et al., 2017; Valizadeh & Hayati, 2021).

In addition, the farm-level theme was produced because most studies focus on farmers or individual field owners as the unit of assessment. This aims to provide the extension service with a diagnostic tool or information to identify areas for improvement. For the methodological approach or construction theme, most studies show that index construction or assessment follows the guidelines for composite index development (Joint Research Centre, 2008), starting with the adaptation or construction of the theoretical framework, indicator selection, normalisation, weighting, aggregation, and sensitivity analysis. However, several studies did not explicitly describe their sensitivity analysis procedures, which is important for the reliability of the tools (Bonny & Vijayaragavan, 2001; Castoldi & Bechini, 2010; Defiesta & Rapera, 2020; Mohamed et al., 2016; Sabiha et al., 2016; Terano et al., 2015). Greco et al. (2019) stated that the criticism of the index's development lies in its weighting and normalisation; thus, sensitivity analysis is less of a focus. Moreover, this approach is computationally expensive, requiring many simulations to produce reliable results (Cacuci & Ionescu, 2004).

2.6.2.2 SWOT Analysis of Global Index

Several sustainability index developments and assessment conducted by previous developers, as shown in the summary of the SWOT analysis presented in Table 2.10. The SWOT analysis demonstrates that previous indices adapted multidimensional assessment methods and provided methodological contributions for sustainability assessment. However, there are several limitations arising from the developed index, such as theoretical foundation, methodological transparency, and robustness of the assessment tools. Most indices lack sensitivity and uncertainty analysis needed to show robustness of the index; context-specific indicator unable to adapt to other contexts, and procedure transparency on aggregation of indicators is not presented. Therefore, future sustainability index development should emphasise comprehensive methodological procedures such as criteria selection, indicator validation, normalisation, weighting, aggregation, robustness test, and result interpretation. By improving the comprehensiveness of the index procedure, reliability enhancement, transparency, and an applicable sustainability index.

Table 2.10
Past Index Development and Assessment Analysis

Author	**Christo et al., 2025**	**Intan Salassa et al., 2025**	**Guo et al., 2022**	**Valizadeh & Hayati, 2021**	**Rahayu et al., 2025**
Strength	• Multidimensional • Large sample size • Uses official secondary data • Captures spatial sustainability variation	• Multidimensional • Used RAPFISH/MSD methodology • 225 rice farmers • Identified key leverage factors affecting sustainability	• Multidimensional • Provide index development guidelines • Applicable to all farming sectors	• Performed reliability and stability testing • Validated sustainability indicator • Strong methodological rigour • Conducted PCA and CFA analysis.	• Multidimensional • Used RAP-MDS with reliability testing • Identified sustainability leverage attribute factor
Weakness	• All indicator weights	• Based on scoring and	• No field validation	• Limited	• Context-specific

	are equal • No sensitivity and uncertainty analysis • Reliance on one source of data availability • Results focused on spatial distribution and sustainability ranking	perception-based assessment. • Limited theoretical alignment • Not reporting weighting procedure • Context-specific study area • Potential subjectivity from expert judgement • No sensitivity and uncertainty analysis	• Conceptual study • Requires extensive data availability • No sensitivity and uncertainty analysis applied	transferability • Context specific to Iran • No sensitivity and uncertainty analysis • Reliance on one source of data collection • Aggregation procedure not explained • No threshold value classification	study area • Limit generalisation • No sensitivity and uncertainty analysis • Reliance on one source of data collection • Limited theoretical alignment • Normalisation and weighting procedure not reported
Opportunity	• Incorporate statistical weighting • Conduct sensitivity and uncertainty analysis • Farm-level indicator adaptation • Application index to another context • Development of benchmark	• Expand to district or national level • Convert into composite index • Introduce weighting and normalisation • Conduct longitudinal assessment • Integrate climate and digital agriculture indicators	• Apply empirical test • Include sensitivity and uncertainty analysis	• Apply validation to other crops and regions • Include sensitivity and uncertainty analysis • Develop threshold value classification • Explicitly define aggregation procedure	• Extend framework to other rice varieties • Include economic resilience and market competitiveness • Monitoring across multiple regions • Integrate consumer acceptance and market demand indicators
Threat	• Changes in data availability may affect index continuity • Climate change may affect indicator	• Sensitive to scoring and expert judgment of RAPFISH • Climate change may affect indicator relevance	• Limit adoption • High data requirement may restrict practicality • Different methodological choices may produce differ	• Selected indicator limited to Iranian wheat farming • Absence of sensitivity and uncertainty analysis reduces	• Selected indicator limited to Iranian wheat farming • Climate change may affect indicator relevance

	relevance • Equal weighting may produce different conclusions • Regional assessment may not represent farm-level	• Limited transparency of MDS calculation may reduce stakeholder acceptance	interpretation	index robustness • Indicator priorities may change over time.	• Market and policy changes may affect sustainability outcomes

2.6.3 Malaysian Index Context

The sustainability index in Malaysia showed an uptrend from 1993 to 2025, as shown in Figure 2.8. Before 2005, scholarly work published was very low and inconsistent, but from 2006 to 2010, there was a small increase, although still limited. From 2011 to 2015, there was a moderate increase, while from 2016 to 2023, there was a clear and continuous surge in the publication of scholarly work. This uptrend shows that researchers have increasingly adopted this sustainability index in the Malaysian agricultural sector, especially in the current era of globalisation, which supports the concept of sustainability as proposed by the United Nations in the SDGs framework.

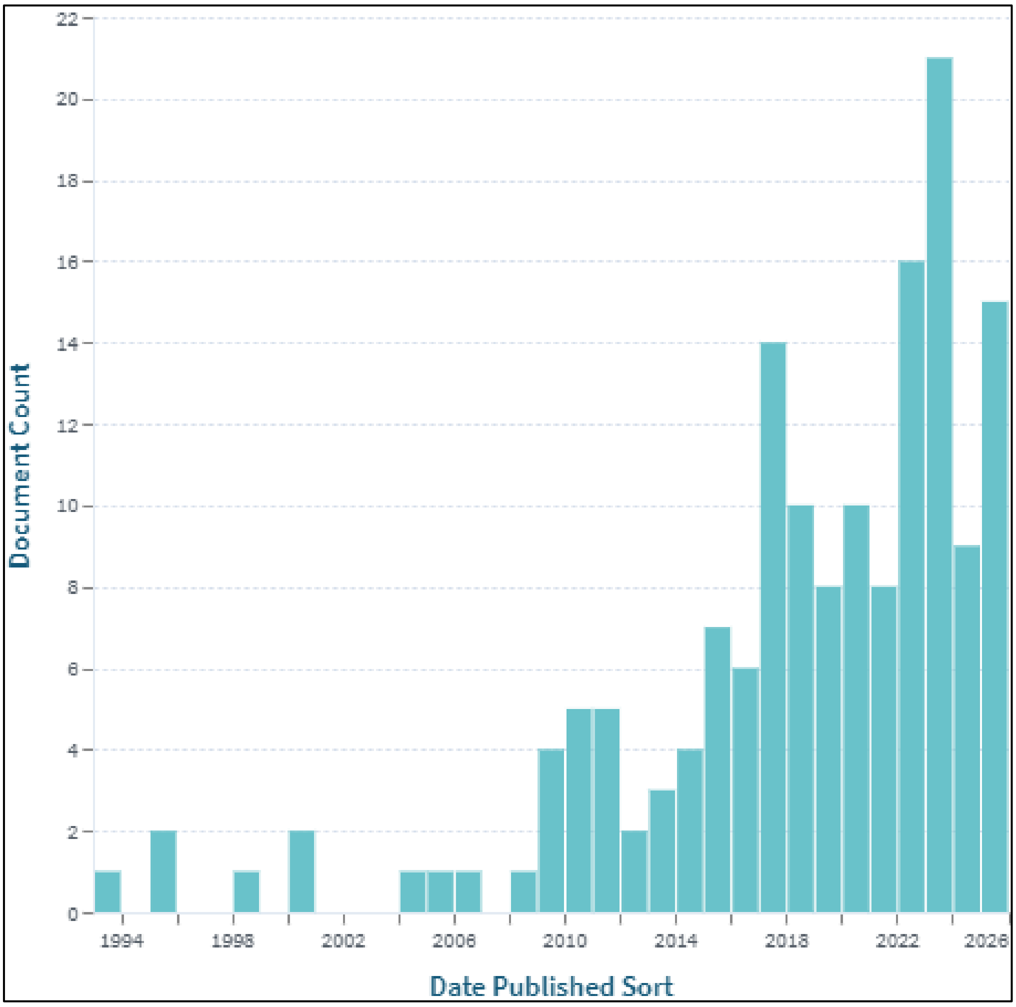


Figure 2.8 Number of Publications Per Year in Malaysia

The subject word cloud in Figure 2.9 shows that this scholarly work is multidisciplinary, with a focus on agriculture and the environment. In agronomy and crop science, 8 are the most dominant because of their focus on crop practices, productivity and agricultural management. For Geography, Planning and Development and Multidisciplinary, six studies integrate spatial aspects and development planning. Management, Monitoring, Policy, Law, and General Medicine: five studies demonstrate elements of health and health implications in the study. Next, General Environmental Science and Plant Science emphasise the importance of the environment and biodiversity as the basis of the study. For other themes, although in small numbers, it indicates the use of technical, analytical and quantitative approaches. Thus, this cloud visualises past scholarly work on agriculture and sustainability by combining various elements.

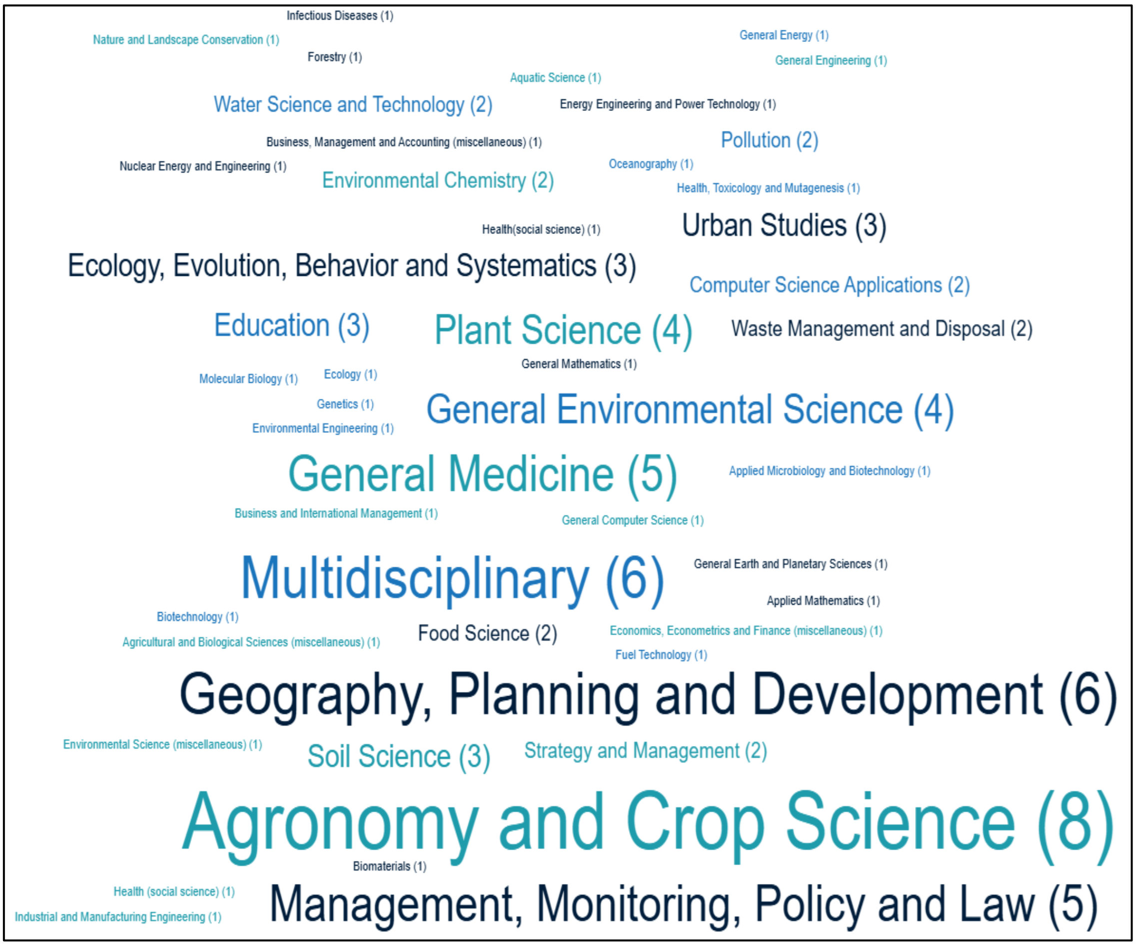


Figure 2.9 Past Studies on The Cloud Work Subject

2.6.3.1 Selected Index in Malaysia Context

There are 6 prior studies presenting sustainability index models that were selected for an overview and thematic descriptions. The literature studies were selected because they were relevant to the agricultural cultural context and the relationships among variables in rice cultivation, as shown in Table 2.11, Malaysia index matrix.

Table 2.11
Malaysia Index Matrix

Author	Framework Used	Dimension Focus	Crop Studied	No. of Indicators	Normalization Method	Weighting Technique	Aggregation Technique	Sensitivity & Uncertainty Analysis	Index Model Name
Keyvanfar et al. (2020).	Not explicitly mentioned, adapt based sustainability framework	Economic, Environmental and Social	Urban farming crops (Vegetables and fruits).	3 criteria and 15 sub-criteria (18 total).	Summing entries in columns and dividing by the sum to yield a normalised score.	Analytical Hierarchy Process (AHP).	Weighted Sum Method (WSM).	Not mentioned explicitly.	Sustainable Urban Farming Index Assessment (SUFIA)
Jamaludin et al. (2018).	Mentioned adapt based on the sustainability framework	Economic, Environment and Social	Oil Palm (Palm oil mills).	14 parameters and 41 indicators.	Proximity-to-Target (PTT) measures distance to policy targets (Scale 0–100).	Expert survey method; assumed equal weightage for parameters.	Linear aggregation from indicator to parameter, aspect, and final index score.	Not mentioned explicitly.	Palm Oil Mill Sustainability Index (POMSI)
Taylor et al. (1993).	Not explicitly mentioned; adapted-based	Environment	Cabbage (Brassica oleracea	33 production practices.	Linear adjustment to 0–100 scale (Total	Iterative expert consensus	Simple addition of individual	Correlation between the variable and	Farmer Sustainability Index

	sustainability framework		capitata).		score * 100/82).	and subjective team judgment.	practice component scores.	external validation	(FSI).
Ajidasile (2015)	Not explicitly mentioned, adapt based sustainability framework	Economic, Environmental, and Social	Rice (Paddy).	Not mentioned explicitly.	Adjusted to a 0–100 scale.	Scoring is assigned to practices via Excel.	Not mentioned explicitly.	Not mentioned explicitly.	Agricultural Sustainability Index (ASI).
Mohamed et al. (2016).	Used the Rice Check guideline by the Department of Agriculture, Malaysia.	Environment	Rice (Paddy).	16 farming practices.	Recalibrated scores to a range of 0–100 based on discrete categories.	Weighted based on perceived influence on sustainability (positive/negative values).	Summation of sustainability scores across the farming process.	Not mentioned explicitly.	Farmer Sustainability Index (FSI)
Kamaruddin & Abd. Rashid (2025)	Used the Rice Check guideline by the Department of Agriculture, Malaysia.	Environment	Rice (Paddy).	10 RC components and 68 production practices.	Percentage conversion (Total Score / 68 * 100) on a 0–100 scale.	Binary scoring (1 if performed, 0 if not).	Percentage conversion of total recalibrated scores.	Not mentioned explicitly.	Sustainable Farm Management Index (SFMI).

Based on Table 2.11, past studies show that the assessment and development of the index are carried out using a structural approach to measure agricultural sustainability, from conceptual definition to mathematical validation. The matrix yields several themes, such as the multi-sustainability dimension, as noted by Ajidasile (2015), Jamaludin et al. (2018), and Keyvanfar et al. (2020), who stated that their index is based on these 3 dimensions to provide a holistic view of their assessment context. On the other hand, Kamaruddin & Abd. Rashid (2025), Mohamed et al. (2016), and Taylor et al. (1993) only focus on the environment. Next, in the sustainability framework foundation theme, only Jamaludin et al. (2018) stated that their assessment's foundation aligns with international and local sustainability frameworks, unlike many index developers. Thus, a strong foundation-based sustainability framework aligned with the sustainability goals of the local and international contexts increases the index's reliability. In addition, the diverse indices share the following themes: indicator selection, weighting, normalisation, aggregation, and sensitivity and uncertainty, as outlined by the OECD. Different techniques were used in each of the index procedures chosen by the developer to suit the study's context.

2.6.3.2 SWOT Analysis of Malaysian Rice Index

SWOT analysis has been adapted in this literature review of Malaysia rice index (Benzagtha et al., 2021; Gurel & Tat, 2017). Usually, this analysis was done to evaluate an organisation's market position (Rozmi et al., 2018), but this method can be used to assess the strengths and weaknesses of a model. 3 rice index models have been developed by past developers that were selected for analysis, namely Sustainable Farm Management Index (SFMI), Agricultural Sustainability Index (ASI), and Farmer Sustainability Index (FSI) (Ajidasile, 2015; Kamaruddin & Abd. Rashid, 2025; Mohamed et al., 2016). Table 2.12 shows the SWOT analysis of the three Malaysian rice index models.

Table 2.12
SWOT Analysis of Malaysian Rice Index Model

Author and Index	**Sustainable Farm Management Index (SFMI)/ Kamaruddin & Abd. Rashid (2025)**	**Farmer Sustainability Index (FSI)/ Mohamed et al (2016)**	**Agricultural Sustainability Index (ASI)/ Ajidasile, 2015**
Strength	• Recent index. • Large sample size (500 Farmers). • 3 major granaries (MADA, KADA, IADA BLS). • Criteria based on Malaysian Rice	• Simple and understandable scoring system (0-100) • Criteria based on Malaysian Rice Check Guideline • Focus on safety and chemical use	• Large sample size (402 farmers) • Use regression analysis • Investigate determinants affecting sustainability practices • Strong empirical data from

	Check Guideline. • Represents sustainability practices from an agronomic perspective.	• Practical application for extension and policy programs • Empirical data from MADA granary	MADA granary • Focused on practical farming sustainability issues
Weakness	• Focused on farm management, rather than comprehensive sustainability dimensions. • Limited discussion on social sustainability. • Limited methodological approach in index aggregation. • Heavy dependence on rice check compliance. • Less emphasis on 3-pillar sustainability concepts. • Few identified weak areas of indicators	• Small sample size (80 farmers) • Compliance-based assessment • Limited multidimensional integration • Simple scoring and aggregation approach • Weak theoretical underpinning • Limited validation and robustness analysis • Heavy dependence on rice check compliance • Less emphasis on 3-pillar sustainability concepts • Few identified weak areas of indicators	• Limited mathematical aggregation process • Basic sustainability scoring • Limited methodological approach in index aggregation • Lack of alignment with sustainability framework • Heavy focus on environmental indicators rather than economic and social indicators. • Less emphasis on 3-pillar sustainability concepts • Fewer identified weakness area of indicators
Opportunity	• Expand to more comprehensive multidimensional index criteria and indicators. • Integrate dimensions equally. • Integration of index aggregation. • Alignment of sustainability framework.	• Expand to more comprehensive multidimensional index criteria and indicators. • Integrate dimensions equally. • Integration of index aggregation. • Alignment of sustainability framework.	• Expanded to more comprehensive multidimensional index criteria and indicators. • Integrate dimensions equally. • Integration of index aggregation. • Alignment of sustainability framework.
Threat	• Potential Biases toward social and	• Potential Biases toward social and	• Potential Biases toward social and

economic dimensions • May reduce index relevance due to simpler aggregation • May fail to capture interconnectedness of sustainability • May provide limited diagnostic capability due to less emphasis on specific indicator weaknesses	economic dimensions • May reduce index relevance due to simpler aggregation • May fail to capture interconnectedness of sustainability • May provide limited diagnostic capability due to less emphasis on specific indicator weaknesses • May not be able to generalise the result	economic dimensions • May reduce index relevance due to simpler aggregation • May fail to capture interconnectedness of sustainability • May provide limited diagnostic capability due to less emphasis on specific indicator weaknesses

Based on Table 2.12 above, the SWOT analysis indicated the current sustainability index model in Malaysian rice offered a basis for assessment for practical, empirical support, and locally relevant context. However, limitations were identified, such as a lack of integration of environmental, social and economic factors, insufficient methodology clarity, inadequate validation procedure, and absence of detailed indication-level evaluation. These gaps create opportunities for the development of more comprehensive sustainability index models able to capture the multidimensional aspect of sustainability and enhance decision-making. If this limitation is still not addressed, sustainability assessment may continue to become incomplete, which reduces its effectiveness in guiding policy development, continued monitoring, and sustainability improvement efforts. Therefore, the analysis supports the development of a new sustainability index as a holistic, locally relevant, and context-specific tool for assessing the sustainability performance of Malaysian rice farmers.

2.7 Research Gap on Malaysian Rice Index

Based on a bibliometric analysis, the trend of index development in the agriculture sector is increasing globally and in Malaysia. Various indices have been developed using different techniques, each adapted to the basic index development procedure. While the SWOT analysis focuses on index development in Malaysian rice farmer cultivation, it identified several research gaps that require attention, as outlined below.

2.7.1 Conceptual Gap

The existing index model is limited to multidimensional sustainability integration. Focusing on cultivation practices and productivity, driven by rice check compliance, compared to integrating environmental, social and economic sustainability dimensions as a balanced framework. This study has more emphasis on management, which is less on the well-being of farmers, resilience, health and safety, and ecosystem balance. Therefore, the current index is weak in providing a holistic picture of sustainability performance of rice farmers.

2.7.2 Theoretical gap

Next, this index model's is also a weak theoretical foundation for index development. Found to be practice-driven rather than theory-driven. Criteria and indicators selected based on general and rice check guidelines are not aligned with sustainability pillars, which are environmental, economic and social, and the sustainability framework. Thus, misalignment with sustainability concepts and framework limit index ability to monitor and promote sustainability effectively (Fredericks, 2013).

2.7.3 Methodological Gap

Further, there is limited integration of aggregation methods in index construction. The studies used simple scoring systems and basic aggregation methods. There is limited application of weighting, normalisation and index algorithms, and threshold determination as prescribed by the Joint Research Centre (2008) on index development. The model inadequately presents how indicators are mathematically integrated into an index model. Integrating these aggregation or mathematical approaches to index development was necessary to maintain relevance and accurately monitor the intended indicators (Usubiaga-Liaño & Ekins, 2024).

2.7.4 Empirical gap

While on empirical gap, limited contextual representation. Two models focus on MADA granary areas that were context-specific to the state of Kelantan. One model focuses on 3 granary (MADA, KADA and IADA BLS) areas with less emphasis on social and economic dimensions. The index was influenced by the local rules, regulations, practices, and climate conditions. The sustainability index shall be conducted at specific spatial and temporal scales (Gan et al., 2017). These limitations inadequately capture the sustainability performance of rice farmers in IADA BLS, Selangor. Thus, the need for a more comprehensive sustainability index assessment that reflects the contextual characteristics of IADA BLS granary areas through integrated environmental, economic, and social dimensions.

2.7.5 Index Model for Malaysian Rice Farmers

The current study developed a potential new sustainability index for Malaysian rice-farmer cultivation practices. The study implemented the procedure as stated in the review, including the development of theoretical sustainability criteria, indicator selection, normalisation, weighting, aggregation, and result interpretation. The new sustainability index is named "Malaysia Sustainable Rice Index (MySRI) as shown in Table 2.13.

Table 2.13
Malaysia Sustainable Rice Index (MySRI) Component

No	**Item/ model**	Malaysia Sustainable Rice Index (MySRI)
1	Agriculture crop	Rice
2	Issue of study	Environmental, social, and economic issues
3	Method of data collection	Literature review, Interview, and Survey
4	Level of assessment	Farm level/Granary

5	Sustainability criteria	Zero burning practices, Water resources, Pre-planting, Harvesting and post-harvesting, Efficiency of energy use, Waste management and disposal, Planting material, Pest Input control, Fertiliser Input, Species Diversity, Traceability, Stability of Production, Stability of Supply, Liquidity, Value Creation, Quality of Life, Capacity Development, right to use land, Employment condition, Workplace safety
6	Procedure of index development	Theoretical criteria selection Indicator selection Normalization Weighting Index calculation Result interpretation

2.8 Theoretical Framework of Sustainability Index Development.

Therefore, this study introduces a new theoretical sustainability framework or set of criteria for rice-farmer practices in Malaysia, serving as a basis for sustainability assessment using the sustainability index. This framework or set of criteria is adapted from the five (5) sustainability frameworks, aligned with current practices, rules, and regulations, as explained in detail in the methodology section. Framework or criteria based on the sustainability concept, with three (3) pillars: environmental, economic, and social, and its main indicator, as shown in Figure 2.10.

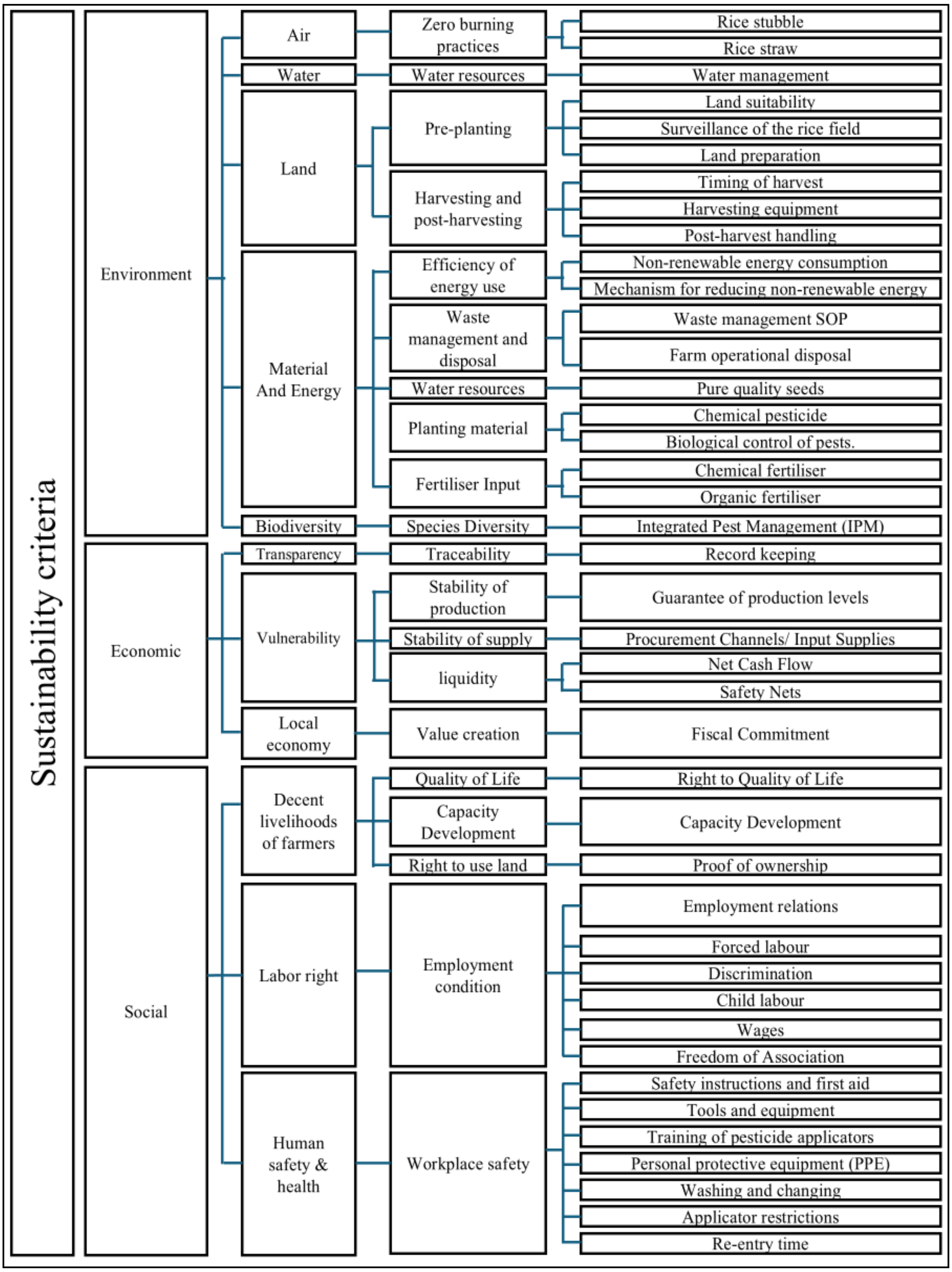


Figure 2.10 Theoretical Sustainability Framework or Criteria

2.9 Conceptual Framework of Sustainability Index Development

Based on the above review of the literature and theoretical perspective, the researcher presented the foundation of sustainability and a sustainability assessment focused on the sustainability index. The researcher has elaborated on the elements within the sustainability concept and the intent to develop an index. The concept of sustainability has become the foundation for sustainable development. Therefore, the study's conceptual framework is illustrated in Figure 2.11 below.

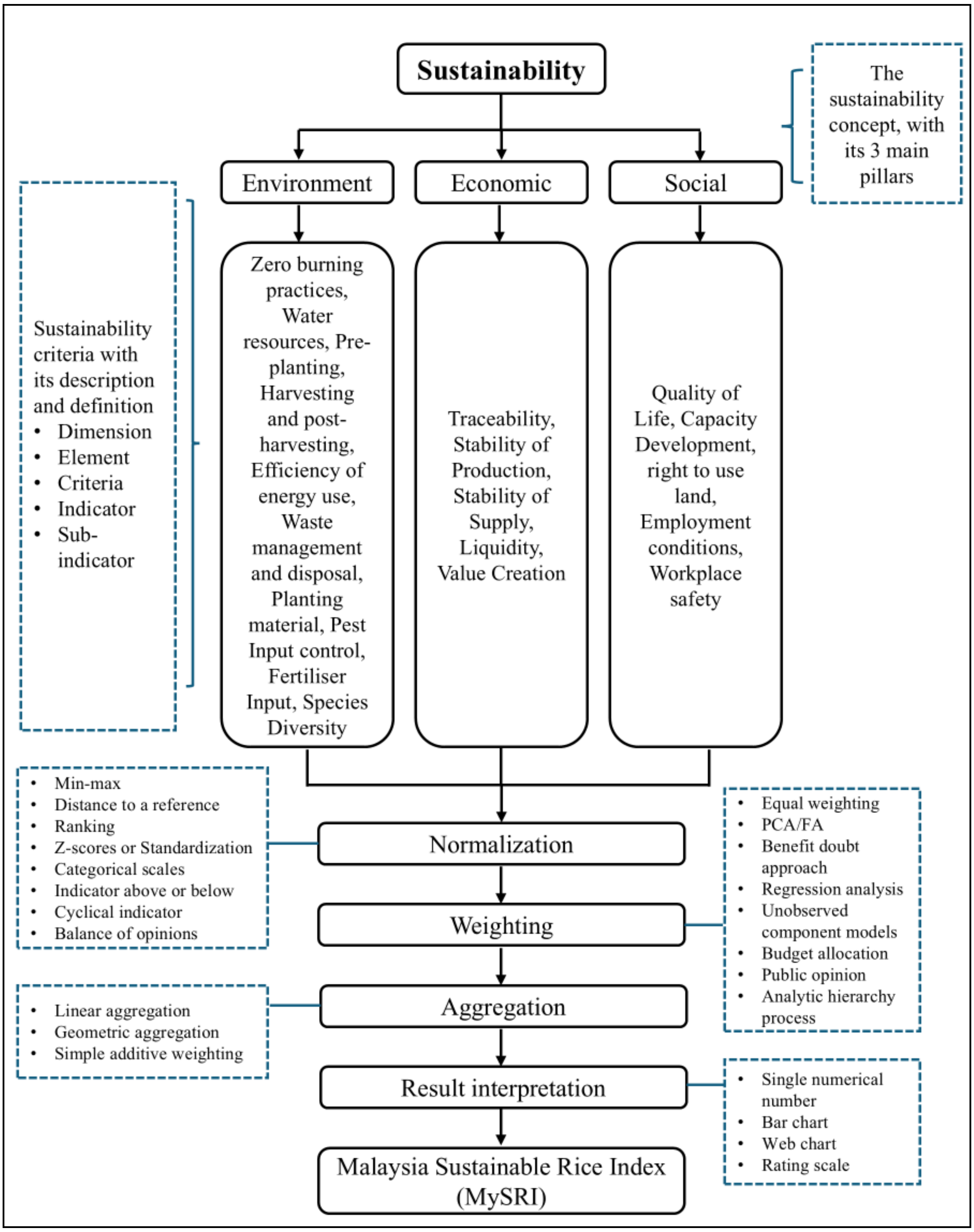


Figure 2.11 Conceptual Framework of Sustainability Index Development

2.10 Chapter Summary

This chapter critically reviewed past literature on sustainability, sustainable agriculture, sustainability assessment, and index development, with a focus on rice cultivation in Malaysia. This review demonstrates that various sustainability indices have been developed, but they inadequately capture the multidimensional and context-specific nature of farm-level rice cultivation sustainability. These gaps provided theoretical and methodological justification for developing a new sustainability index tailored to Malaysian rice farmers, elaborated in the methodology chapter.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents and explains the research methods used to develop a sustainability index for rice farmers' agricultural practices in Malaysia. Given the multidimensional, context-specific, and normative nature of sustainability, the methods adapted for this study prioritise methodological rigour, transparency, and measurable, replicable outcomes. The chapter explains the research design, data sources, analysis procedures, and validation approach to support the development of a credible and contextually relevant index.

The methodology is structured in three phases of index development. Phase 1 focused on identifying sustainability criteria and indicators aligned with established sustainability frameworks and current agricultural practices. Phase 2 validated the identified criteria using expert opinion to ensure relevance and alignment with context. Phase 3 involved index development using structured mathematical procedures and application at the farm level. Overall, these phases ensure that the developed index is theoretically grounded, empirically operationalised, and suitable for assessing sustainability performance among rice farmers in Malaysia.

3.2 Research Paradigm

This research was guided by the pragmatist research paradigm, which emphasises practical problem-solving, methodological diversity, development of knowledge and the use of appropriate approaches to address the research problem and objective (Biesta, 2010; Goles & Hirschheim, 2000; Kaushik & Walsh, 2019; Morgan, 2007). This paradigm has been considered because this research focuses on the development and evaluation of a sustainability index for rice farmers' cultivation practices in the Malaysian context. Agricultural sustainability was multidimensional and required systematic, contextually relevant assessment approaches. Therefore, pragmatism supports the operationalisation of the sustainability concept into measurable indicators and a practical assessment framework suitable for informed decision-making and policy evaluation (Franks & Frater, 2013).

This paradigm also supported the integration of qualitative and quantitative approaches in sustainability assessment (Peace et al., 2018). Therefore, qualitative approaches were important for establishing sustainability criteria and indicators based on identified frameworks, guidelines, and practices in rice cultivation. Which quantitative approaches enable sustainability assessment and index construction through structured measurement and mathematical algorithm procedures. This integration of multiple approaches ensures the developed index is aligned with the sustainability concept, contextually relevant and empirically measurable.

In addition, the pragmatism paradigm offers several features to enhance methodological rigour and research credibility by providing transparency, contextual relevance, and ethical practices (Giacobbi et al., 2005; Kelly & Cordeiro, 2020; Suter & Cormier, 2013). This research incorporated sustainability frameworks, guidelines, empirical studies, expert validation, interviews, surveys, and open-access government documents throughout the process to evaluate and develop a sustainability index. Therefore, the pragmatist paradigm has provided a suitable philosophical basis for the systematic assessment and practical application of sustainability assessment in the context of Malaysian rice cultivation.

3.3 Research Design

This study adopted a mixed-method research design (Creswell, 1999; Johnson & Christensen, 2014). Based on sequential phases, qualitative and quantitative approaches were integrated to develop a sustainability index for paddy farmers' cultivation practices in Malaysia. This mixed-methods research design was chosen to integrate sustainability concepts with empirical assessments and to develop the sustainability index process. Several index developers had applied sequential phases (Jamaludin et al., 2018; Valizadeh & Hayati, 2021). This research design consisted of three sequential and interrelated phases according to the study objectives, as shown in Figure 3.1.

Phase 1 focused on identifying and analyzing sustainability criteria and indicators for rice farmers' cultivation practices, drawing on sustainability frameworks, guidelines, empirical studies, and current practices. In Phase 2, experts were engaged to validate the sustainability criteria, indicators, and sub-indicators identified to ensure their relevance and contextual suitability for rice cultivation in Malaysia. Phase 3 has focused on sustainability assessment and the development of a sustainability index using quantitative survey methods and mathematical algorithms. Each phase was sequentially dependent, with outputs from earlier phases forming the basis for subsequent phases' methodological procedures and sustainability assessment processes.

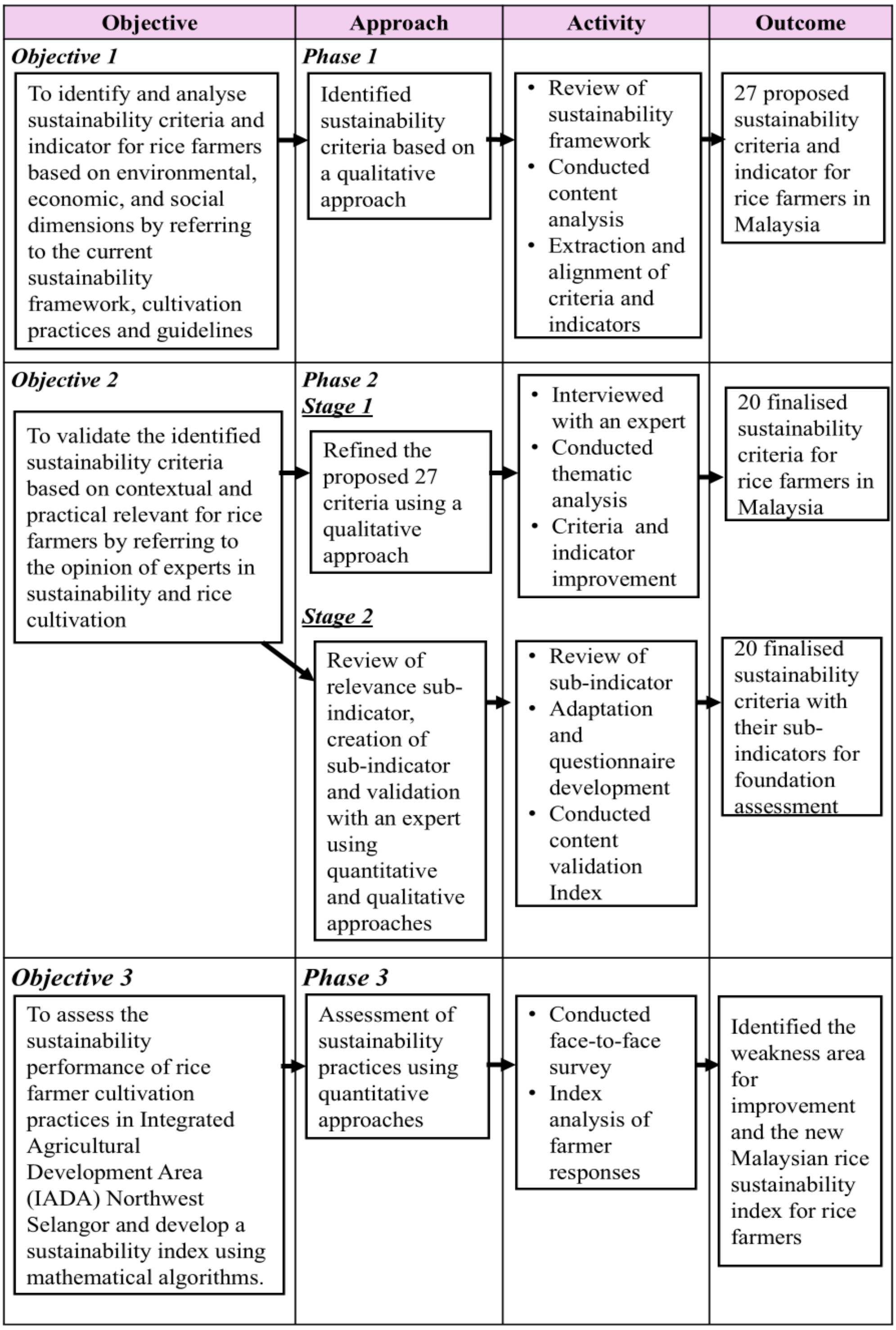


Figure 3.1 Overall Research Methodology Flowchart (Created by The Researcher)

The phased structure of the research design enables a systematic progression from establishing sustainability criteria to expert validation and empirical assessment of sustainability. Additionally, mixed-method integration across the research phases ensures that multidimensionality is addressed, reduces redundancies, facilitates participatory approaches, and bridges theory and practice (Abed et al., 2025; Angilella et al., 2018; Claasen et al., 2015; Shari & Soebarto, 2017; Ustaoglu et al., 2025). To ensure methodological rigour in the development of this index, this research has employed methodological and data-source triangulation by integrating sustainability frameworks, guidelines, empirical studies, expert validation, interviews, surveys, and open-source government documents across the research phases. The use of various methods and information can reduce biases in the selection of criteria, indicators and assessment procedures. Various researchers have used mixed-methods research in agriculture and in the development of rice sustainability indices (Bonny et al., 2010; Rohaeni et al., 2021; Valizadeh & Hayati, 2021), combining these methods in indicator selection, validation, and index algorithm construction.

3.4 Phase 1: Exploration of Sustainability Criteria and Indicators.

Phase 1 has focused on establishing the conceptual foundation for developing sustainability by identifying sustainability criteria and indicators relevant to rice farmers' cultivation practices in Malaysia. This phase aimed to fulfil the first objective of this research: to establish sustainability criteria for rice farmers by drawing on current agricultural practices and the sustainability framework. The establishment of criteria and indicators is important because sustainability assessment needs to be conceptually grounded and capable of representing the environmental, economic, and social dimensions of rice cultivation practices. This ensures criteria and indicators are not developed based on individual judgment or observation. Therefore, the identification process has been done through review and analysis approaches based on selected sustainability frameworks, guidelines and practices. The use of recognised sustainability references enhances the validity, reliability, and policy relevance of indices and improves interpretability and acceptance (Poveda, 2023; Usubiaga-Liaño & Ekins, 2024).

This identification process involved reviewing international and local sustainability frameworks, rice guidelines and practices, and laws and regulations relevant to rice cultivation. Through this process, criteria and indicators have been aligned with current Malaysian practices, rules, and regulations across the environmental, economic, and social dimensions. The results of phase 1 comprise a set of initial criteria and indicators that serve as the basis for the expert validation procedure in phase 2.

3.4.1 Phase Approach

Phase 1 has adopted a qualitative approach, as outlined in the literature review (Evans & Kowanko, 2001), to establish sustainability criteria and indicators relevant to rice farming in Malaysia. The method has been used to develop knowledge, create guidelines for policies and practices, and provide evidence (Snyder, 2019). In addition, the method has been used to help researchers adapt to the objective, research question, and availability of resources. In fact, the method has been used to ensure the trustworthiness and accuracy of the findings (Whittemore et al., 2014). In addition, proposing sustainability criteria and indicators requires identifying, comparing, and synthesizing existing sustainability frameworks or guidelines to produce context-specific frameworks (Kustova et al., 2024).

The literature review approach enables the integration of various sustainability knowledge sources relevant to the Malaysian rice context, including sustainability frameworks, guidelines, regulations, and practices. Thus, these approaches strengthen conceptual alignment with sustainability concepts, contextual relevance, and methodological rigour, and reduce researcher judgment in selecting criteria and indicators for the index. Several previous studies have adapted these methods to establish sustainability criteria or frameworks (Costa et al., 2022; Janjua et al., 2020; Juwana et al., 2012). The review process started with the selection of sustainability frameworks and then moved to trustworthiness.

3.4.1.1 Selection of Sustainability Framework

In this phase, the selection of sustainability frameworks was guided by defined criteria. This study selected five sustainability frameworks, 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), as sources of analysis to obtain relevant criteria for food crop cultivation and rice cultivation. The selected sustainability frameworks were identified based on previous studies (Alaoui et al., 2022; Abdul Majid et al, 2021; Ali et al., 2021; Gharsallah et al., 2021). The selection of the five-sustainability framework is suitable because the sources are from well-recognised organisations that developed them and operate at global, national, and multi-stakeholder certification levels. Therefore, the proposed sustainability criteria and indicators were conceptually grounded in recognised sustainability principles and aligned with widely accepted concepts and policy relevance (Ellis et al., 2014; Nasution et al., 2020; Ruysschaert & Salles, 2014; Sulaiman, 2020; Van Cauwenbergh et al., 2007).

To ensure transparency and reduce bias, the framework was screened and selected against predefined inclusion criteria. The criteria are; a) the framework was required based on three pillars of sustainability, namely environmental, economic and social, enable multidimensional assessment, b) the framework recognized by the country or organization applying the framework, either internationally or domestically, to ensure that the criteria are in line with the sustainability concept and acknowledge assessment standards, and c) demonstrate suitability at the farm production scale level to ensure that the criteria and main indicators can be measured and operational in the context of agricultural management and rice cultivation, despite different commodity focuses. Table 3.1 presents the rationale for the selected sustainability framework.

Table 3.1
Rationale of The Selected Sustainability Framework

	Framework	**MyGAP**	**SAFA**	**MSPO**	**RSPO**	**SRP**
1	Relevance for rice cultivation	Soil, water, nutrient management, IPM, worker and farmer safety, Market opportunity, farm productivity	Soil quality, nutrient management, water resources, biodiversity, greenhouse gases, farmer income, labour, surrounding community, market opportunity, equity	Soil and nutrient management, water management, biodiversity, worker safety and health, fair labour practices, community relations and rights, and financial viability.	Livelihood and income, labour welfare, capacity building, soil and water conservation, input management, ecosystem protection.	Water and soil management, Input management, greenhouse gases, labour safety, equity, yield, production, profitability, market access.
2	Dimension	Environment, economic, and social	Environment, economic, social, governance	Environment, economic, social, governance	Environment, economic, social, governance	Environment, economic, and social
3	Scale	Farm-level	Farm to enterprise	Farm to enterprise	Farm to enterprise	Farm-to-farm group level

			level	level	level	
4	Sector	Crop, livestock, and fishery	Crop, livestock, and fishery	Oil palm	Oil palm	Rice
5	Authority	Department of Agriculture Malaysia	Food and Agriculture Organisation, United Nations	Malaysian Sustainable Palm Oil	Roundtable Sustainable Palm Oil	Sustainable Rice Platform
6	Contextual relevance to Malaysia	Aligned with local laws, regulations, practices, and policy.	Aligned with general practices.	Aligned with local laws, regulations, practices, and policy.	Aligned with general practices	Aligned with rice practices.
7	References	Mohd Arifin et al., 2024; Suharni et al., 2021; Department of Agriculture Malaysia, 2023.	Food and Agriculture Organisation, 2014; Soldi et al., 2019.	Yap et al., 2021; Labansing et al., 2021; Malaysia Palm Oil Certification Council, 2023	De Vos et al., 2021; Roundtable on Sustainable Palm Oil, 2019	Mungkung et al., 2022; Devkota et al., 2022.

In the Malaysian context, MyGAP and MSPO both served as sustainability standards that addressed three dimensions of sustainability. MyGAP focused on agriculture, while the MSPO certification guideline focused solely on the palm oil industry, with some of its criteria also based on MyGAP. This framework was chosen because of its farm-level sustainability management and operational sustainability principles. The inclusion of RSPO strengthened the proposed criteria and main indicator and reduced bias by selecting only the national framework and MSPO concept derived from the RSPO criteria. The SAFA framework was selected for its explicitly stated core pillar of sustainability, along with a governance dimension developed by the Food and Agriculture Organisation of the United Nations; the criteria were stated to be usable for farm-level assessment. While SRP was chosen for its context-specific framework for rice cultivation, it described core sustainability pillars and provided criteria on the farm-level context.

Therefore, the proposed criteria and main indicators are based on an authoritative and context-specific framework for agriculture and rice cultivation. The selected document was retrieved from an open-source document available on its website. Data extraction of sustainability criteria and indicators from the document was conducted using NVivo 15, as shown in Figure 3.2. The use of NVivo 15 software facilitates the easy identification, comparison, and analysis of large volumes of text within each document.

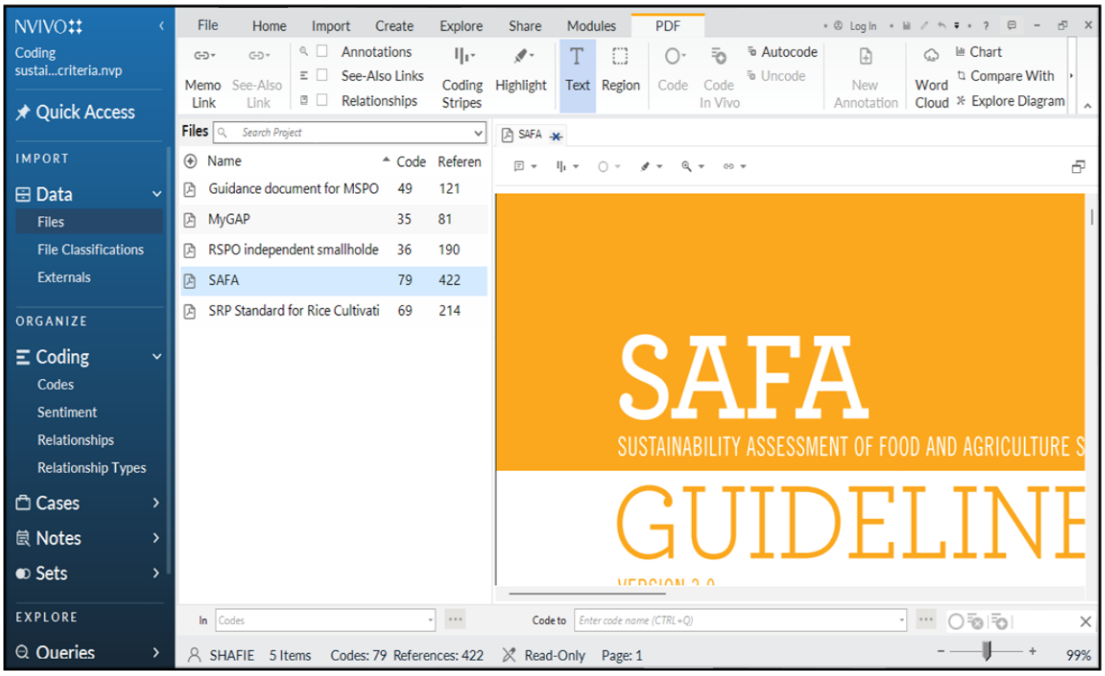


Figure 3.2 Extraction of Sustainability Document

3.4.1.2 Analysis of Sustainability Framework

The qualitative data were analysed using a content analysis approach (Elo & Kyngäs, 2008; Erlingsson & Brysiewicz, 2017; Mayring, 2021). An inductive content analysis approach was adopted, involving open coding, category creation, and abstraction, as shown in the content analysis flow in Figure 3.3 below. The approach facilitated systematic identification and categorisation of sustainability criteria across the selected frameworks. In addition, it facilitates the identification of context-specific sustainability criteria and priorities based on the research topic (Jayarathna et al., 2022). Furthermore, the sustainability framework consisted of a narrative description of sustainability, principles, criteria, and indicators; this approach is suitable for identifying and comparing recurring criteria across the document. Content analysis also increases the transparency of the index development process by stating that the coding procedure, inclusion and exclusion criteria, and indicator traceability are maintained. The use of qualitative content analysis in reviewing the sustainability framework ensures that the proposed criteria and indicators employ a systematic approach and are grounded in a sustainability concept focused on the agricultural and rice sectors.

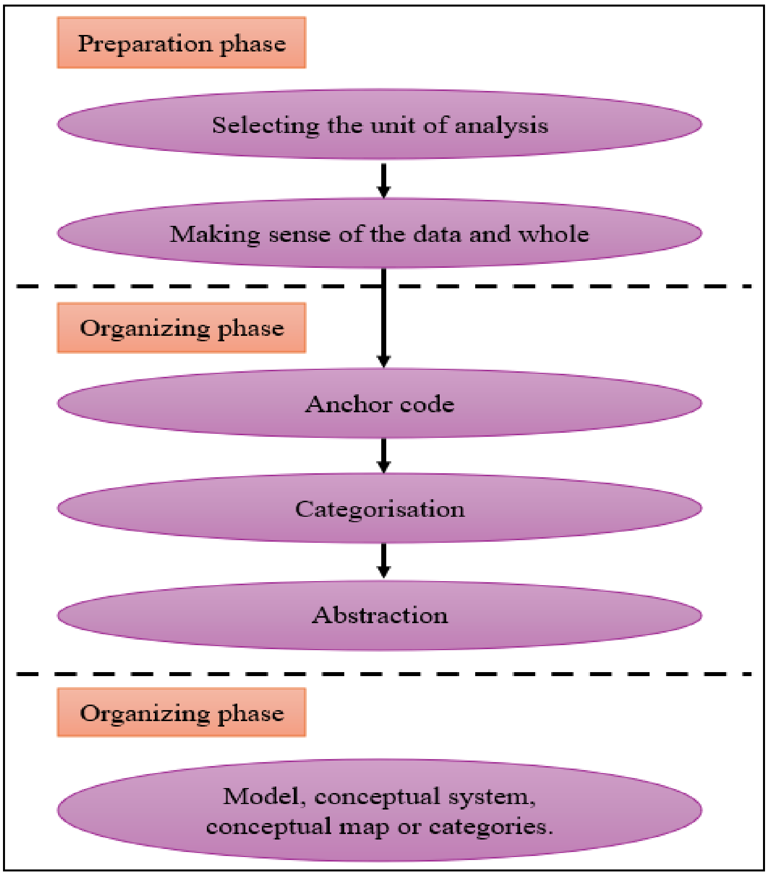


Figure 3.3 Content Analysis Process Flow Modified by The Researcher From (Elo & Kyngäs, 2008)

Based on Figure 3.3, the first step was to select the unit of analysis. The unit of analysis in the approach comprised sustainability criteria and indicators across the environmental, economic, and social dimensions, in accordance with the research objective. Then, the analysis focused on descriptions and definitions of each criterion and indicator based on sustainability frameworks. The unit focused broadly on the detailed criteria and indicators relevant only to rice farmers. The second process involved making sense of the data and the whole. A conceptual understanding overview reading on each sustainability framework, covering its flow, dimensions, principles, criteria, and indicators, twice. The third process involved applying the anchor code (Adu, 2019). The anchor code serves as guidance to ease the development of sub-codes during framework review. The researcher used an anchor code to group the identified sub-codes, using the SAFA framework's dimensions, elements, and criteria as a guiding anchor, as shown in Figure 3.4.

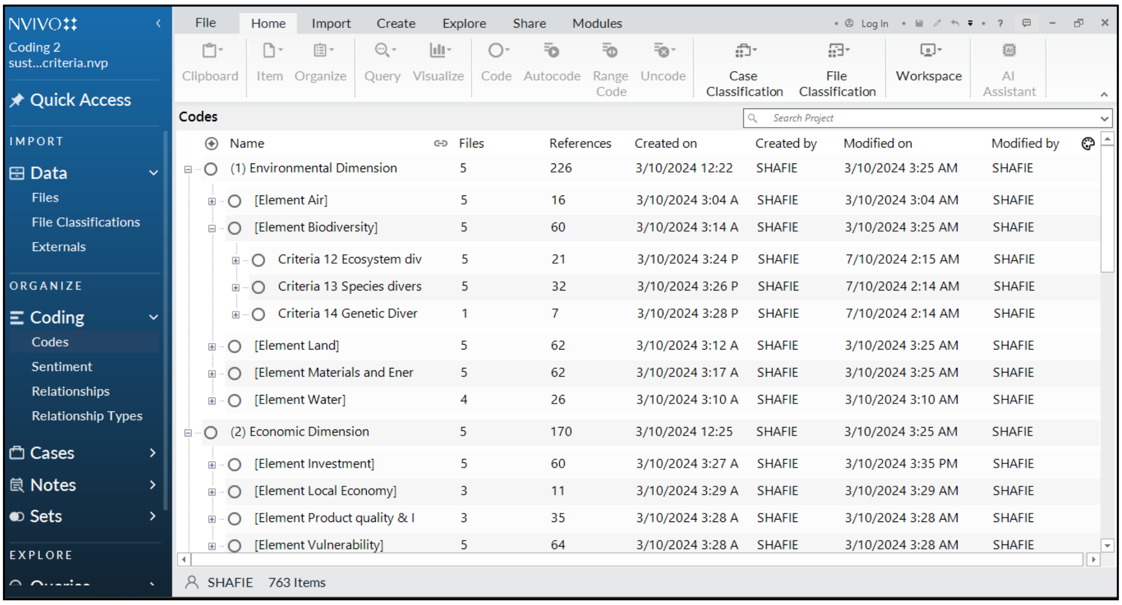


Figure 3.4 Creation of Anchor Code Follows (Adu, 2019)

In the fourth process, categorisation, new codes were identified by reading the document, had meanings similar to the anchor codes, and were inserted into their respective similar-meaning anchor codes. The new code was identified by reviewing the SRP document (Figure 3.5), which shows it was not burned, meeting the criteria for zero-burning practices. In this process, four documents mentioned similar codes regarding zero burning, as excerpted from the SAFA document.

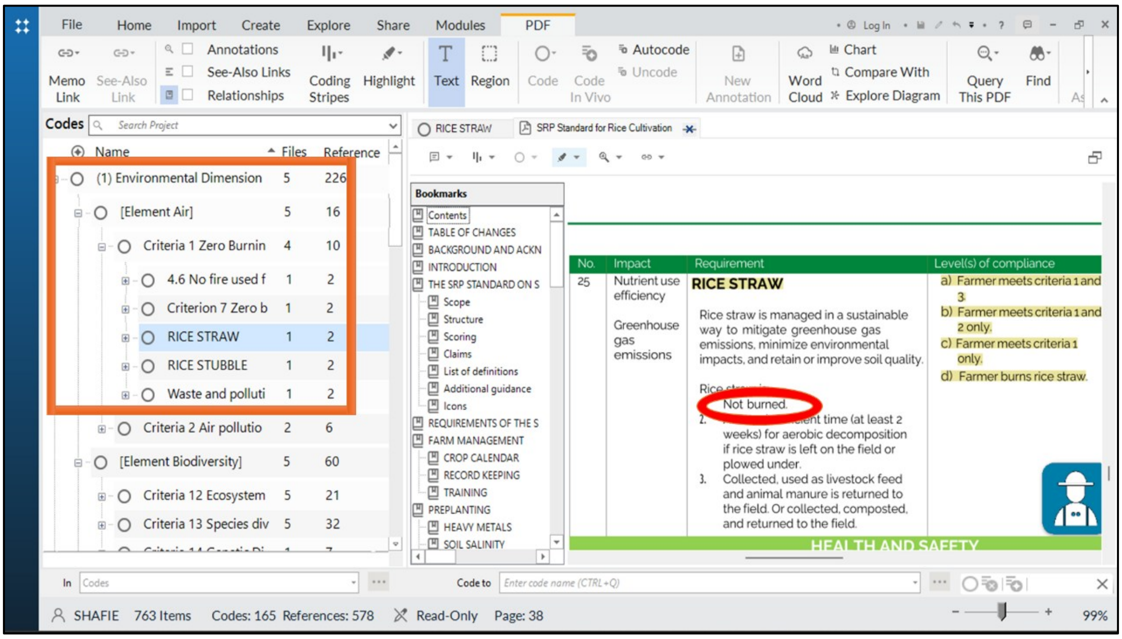


Figure 3.5 Identified New Code Categories in a Similar Anchor Code

The fifth process involved abstraction by formulating general, summarised descriptions of the anchor code and the identified sub-code (main indicator) based on information extracted from the framework. The summarised anchor code and sub-code in NVIVO 15 were exported to Microsoft Excel, then to Microsoft Word for easy description. The final process was the presentation of the model, conceptual concept, conceptual map, or categories derived from the analysis. The framework and its descriptions are presented in Section 4.2.2 of the results.

3.4.1.3 Sustainability Criteria and Main Indicator Extraction

After completing the content analysis of the five selected sustainability frameworks, this study systematically extracts criteria and main indicators. This process aimed to identify and extract criteria and indicators from the conceptual framework derived from the recognised sustainability framework. The extraction process was conducted systematically to ensure the identified criteria and indicators were aligned with the sustainability dimensions and relevant to rice farmers' cultivation practices in Malaysia.

The extraction process was guided by predefined inclusion and exclusion criteria to reduce researcher subjectivity during the selection of criteria and indicators. The first inclusion criterion was that the criteria and indicators must align with the clear conceptual dimensions defined in this study: environmental conservation, social well-being, and economic resilience. This ensures that criteria and indicators must be based on this framework and aligned with policy, thereby reducing institutional legitimacy. Exclusion criteria involved removing the sustainability criteria and main indicators focused on macro-level governance or broader enterprise administration, certification, management, and regulatory oversight, as they are not suitable for assessing farm-level scale. Further, the elimination of criteria redundancy across different terminologies, structural hierarchies, and measurability. On the other hand, the extracted criteria were checked against the Malaysia Rice Check Guideline to ensure they aligned with rice farming practices in Malaysia. The extracted sustainability criteria and indicators were systematically documented to provide methodological evidence for the proposed criteria. Each criterion and indicator source was recorded, along with the original framework, dimension, and detailed description, using NVivo software, thereby facilitating source traceability **(see Appendix 1A).** The extracted criteria and indicators were presented in **Appendix 2A** along with the NVivo file link. The criteria and indicators identified through the exclusion screening were documented in **Appendix 3A**. After applying inclusion and exclusion criteria, the finalised proposed criteria and indicators were defined based on their intended sustainability goal, derived from the sustainability frameworks, with a summary of the criteria and indicators presented in the results section. An expert validated the proposed criteria during phase 2, and the finalised criteria and indicators were used to assess rice farmers in phase 3.

3.4.1.4 Trustworthiness

Trustworthiness in phase 1 has been strengthened through a systematic, transparent content analysis procedure throughout the analysis and the extraction of criteria from each sustainability framework. The analysis procedure, coding process, framework selection, extraction, and categorisation have been documented to ensure consistency and reliability. In addition, the results and the analysis procedure were presented systematically in the methodology and results to provide transparency in the establishment of sustainability criteria and indicators. The analysis's credibility was strengthened by reference to international and locally recognised sustainability frameworks and guidelines. The use of various frameworks allows comparison and reduced reliance on single sustainability references.

In addition, the inductive content procedure involved coding, anchor codes, and abstraction to establish criteria and indicators based on identified frameworks. To strengthen methodological rigour and traceability, the extracted criteria and indicators were documented, along with their original framework source, dimension, and information, using NVivo 15 software. The use of predefined inclusion and exclusion criteria and documentation enhanced the transparency of the extraction of sustainability criteria and indicators.

3.5 Phase 2: Refinement of Sustainability Criteria

Phase 2 has focused on validating the proposed sustainability criteria and indicators established in Phase 1 to ensure their contextual and practical relevance for farm-level sustainability assessment in Malaysian rice cultivation. This phase consisted of two distinct stages: (1) Exploration of the relevance of sustainability criteria and indicators, and (2) Exploration, adaptation, and modification of sub-indicator data availability, benchmark/threshold/standard value, and questionnaire development. Phase 1 has established the theoretical and conceptual foundation of the sustainability framework, drawing on recognised sustainability frameworks and guidelines; further refinement is needed to ensure that the proposed criteria and indicators are operationally relevant, measurable, and applicable.

The approaches used are selected to validate and operationalise the criteria and indicators before their application in the sustainability index assessment in Phase 3. Interviews with experts have been conducted to obtain their opinions on the relevance, feasibility, and suitability of the proposed sustainability criteria and indicators. In addition, literature review and context validation procedures were conducted to refine the measurable sub-indicator and develop assessment items, ensuring the instrument's suitability and context validity for farm-level sustainability assessment. In developing assessment tools, such as indices, selecting indicators or criteria requires transparent, well-defined procedures to ensure that the sustainability assessment is relevant and valid (De Olde et al., 2017). Therefore, phase 2 serves to validate the index's theoretical construction, ensuring that the criteria, indicators, and sub-indicators have been confirmed for integration.

3.5.1 Stage 1: Qualitative Interview

A qualitative interview was conducted to validate the proposed review criteria and indicators. The researcher conducted semi-structured interviews to gather data (Adeoye & Olenik, 2021; Kallio et al., 2016). The researcher modified six steps in the sampling procedure and data gathering and improved the criteria and indicators below (Adeoye & Olenik, 2021). The procedure step of a semi-structured interview is shown in Figure 3.6. This expert validation ensured the proposed sustainability criteria and indicators for assessing rice farming practices were considered, considering their disciplinary backgrounds, farming experience, sustainability knowledge, and suitability in the Malaysian context. The interviewees assessed the relevance, clarity, and contextual appropriateness of the proposed criteria and indicators. In addition, the expert interview approach was appropriate for validating these proposed criteria, as experts serve as evaluators, aggregators, anticipators, and confirmers of the intended study (Von, 2023).

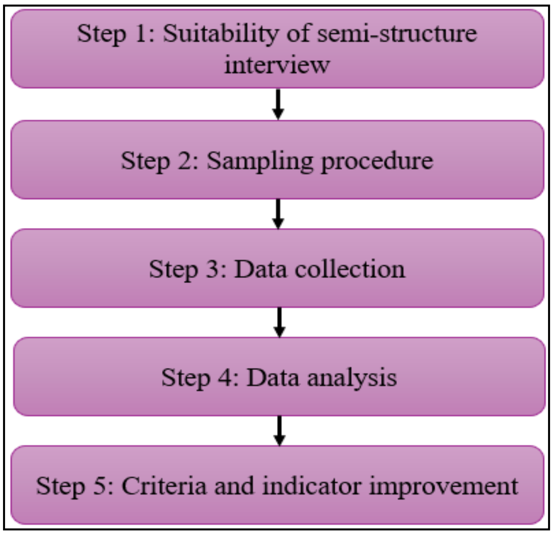


Figure 3.6 Sime-Structure Interview Steps Modified by The Researcher From (Adeoye & Olenik, 2021)

3.5.1.1 Step 1: Suitability of Semi-Structured Interview

Semi-structured interviews have been adapted in stage 1 of this phase 2 to validate the proposed sustainability criteria and indicators from phase 1 for rice farmers' cultivation practices in Malaysia. This approach was considered appropriate because it enabled the inclusion of diverse stakeholder viewpoints, which are essential for creating a practical, contextually relevant framework (Slätmo et al., 2017). Semi-structured interviews were suitable for addressing complex social/behavioural questions and for research that requires greater understanding of the reasons and insights for improvement (Adeoye & Olenik, 2021). Furthermore, semi-structured interviews enable experts to generate plausible explanations, identify vague concepts, highlight contextual limitations, and suggest improvements, whereas survey approaches cannot capture deeper issues. These in-depth findings are important for refining sustainability criteria to ensure they are contextually relevant and achievable. Therefore, this expert interview method is well-suited to producing a framework or set of criteria derived from a professionally validated sustainability framework document (Arushanyan et al., 2017; Gunnarsdóttir et al., 2021).

3.5.1.2 Step 2: Sampling Procedure

The sampling procedure in stage 1 was applied as described by Rai & Thapa (2015). The sampling process consists of: (1) Population of interest identification, (2) Sampling frame specification, (3) Specific sampling method, and (4) Sample size.

1. Population of interest identification: The population chosen in this stage was experts on sustainability and rice cultivation in Malaysia. The expert population was chosen because they help identify contradictions between academic frameworks and farmers' real-world priorities, thereby enabling more effective development and the creation of widely accepted guidelines (Rasmussen et al., 2017).
2. Sampling frame specification: The experts on sustainability and rice cultivation chosen were experts from public universities, government agricultural agencies, agricultural research institutions, and local farmers. The search of the expert based on the online public universities' expert website Universiti Putra Malaysia (UPM), Universiti Teknologi MARA, Universiti Malaysia Sabah (UMS), and Universiti Kebangsaan Malaysia (UKM), online government agriculture agency website Integrated Agricultural Development Area (IADA), online agriculture research institutions Malaysia Agriculture Research and Development (MARDI), and expert referral suggestion (Rice Farmer). An expert was selected based on over five years of experience in rice cultivation practices and research, as well as expertise in sustainability concepts and criteria.
3. Specific sampling method: Non-random sampling was chosen for this stage. Non-probability sampling is a sampling procedure that does not provide a basis for any opinion of probability that elements in the universe will have a chance to be included in the study sample (Etikan & Bala, 2017). The type of non-random sampling used is purposive sampling (Etikan & Bala, 2017; Rai & Thapa, 2015; Tongco, 2007). The specific purposive sampling method used is expert sampling (Etikan & Bala, 2017; Rai & Thapa, 2015). The technique was adapted for feasibility and allowed a focus on a smaller, targeted group of participants, which can save time and resources while yielding high-quality data (Redondo, 2016). Purposive sampling was used to select experts because phase 2 of stage 1 focused on validating criteria and indicators rather than on statistical representativeness. According to Luborsky & Rubinstein (1995), qualitative studies explore people's views of culture, personal meaning, and experience, focusing on the validity of the unit rather than on statistical representativeness. The method was adapted because it assumes that specific individuals hold distinct and important opinions on certain ideas or issues (Campbell et al., 2020).

4. Sample size: Various studies conducted interviews using purposive samples vary in sample sizes (Etikan & Bala, 2017). Thus, the researcher set the sample size to 46, given the researcher's resource constraints. However, 17 samples were finalised because the expert agreed to participate in the interview. The researcher needs to identify appropriate respondents who are willing and able to provide information on their knowledge or experience. (Bernard, 2002; Lewis & Sheppard, 2006).

The experts selected for this interview were chosen for their knowledge of the concept of sustainability, sustainability practices, sustainability assessment, research in the sustainability domain, and the application of sustainability in rice cultivation in the Malaysian agricultural context, as well as across different fields or sectors. Thus, with seventeen experts agreeing to participate in the interview, it provided sufficient conceptual depth to support the validation of the proposed sustainability criteria and their indicators.

3.5.1.3 Step 3: Data Collection

The researcher prepared an activity plan before, during, and after conducting interviews with experts. The preparations included obtaining permission from the research ethics management department (RMC) to conduct the interview study, developing the interview guide, and ensuring data storage. This information needs to be detailed in the research ethics application (Adeoye & Olenik, 2021). The preparations before, during, and after are explained below, and their flow is shown in Figure 3.7.

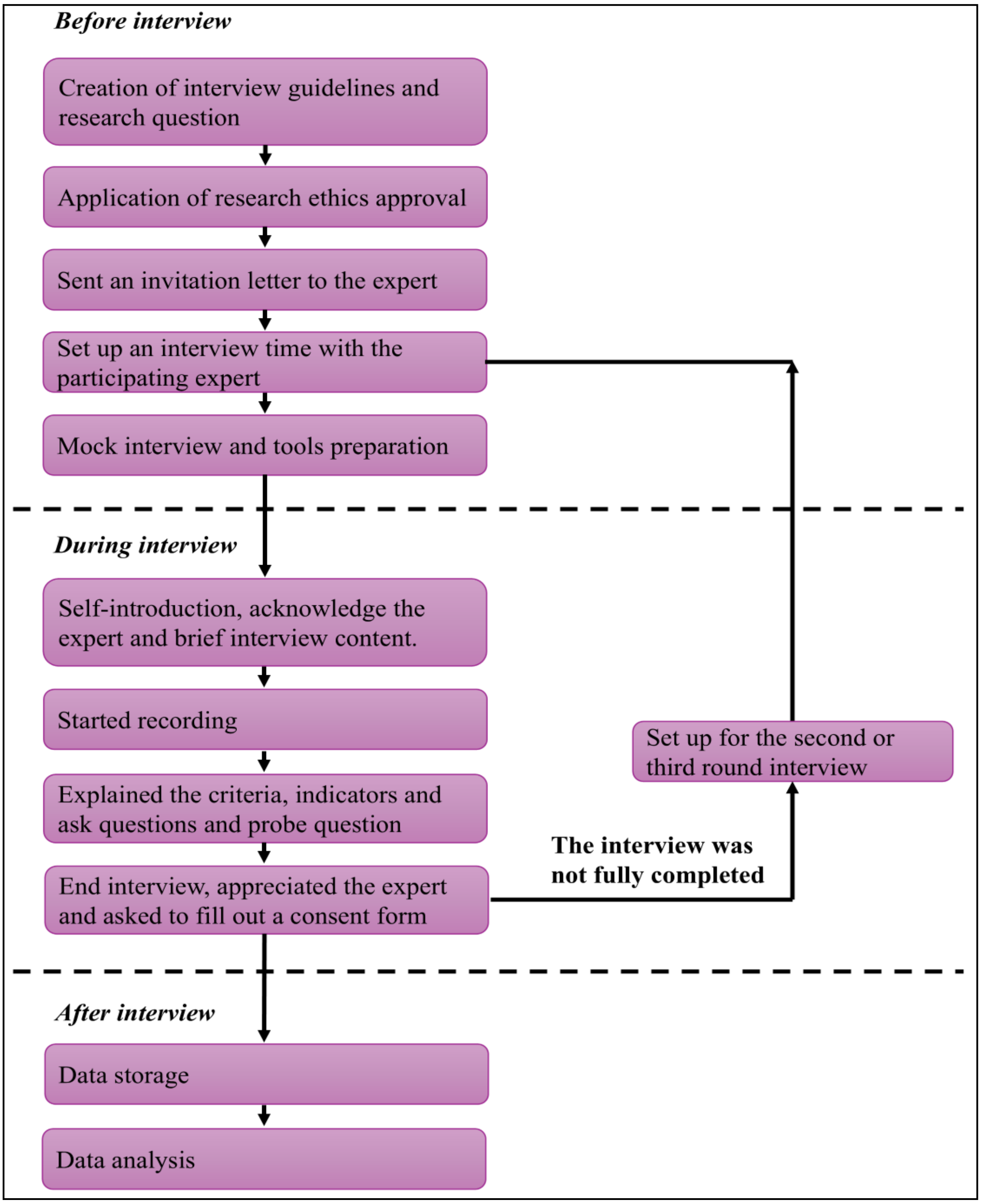


Figure 3.7 Data Collection Flow Preparation was Modified From (Adeoye & Olenik, 2021)

Before the interview, the researcher prepared a set of criteria and an indicator information form, including questions. This information form contains detailed criteria, indicator information, and an interview procedure attached to **Appendix 4A**. For the interview questions, the researcher developed questions aligned with objective stage 1, as shown in Table 3.2. The interview questions that were created only used open-ended questions and probing questions such as “please explain”, “why”, “what”, “ask a suggestion”, etc. A semi-structured interview guide often includes main open-ended questions with follow-up probing questions for the interviewer to refer to throughout the interview (Adeoye & Olenik, 2021). The researcher's supervisor also verified the questions before conducting the interview.

Table 3.2
The Open-Ended Interview Questions

Question 1	"Are criteria one and indicator relevant to be applied in Malaysian rice cultivation at the farm level?"
Question 2	"Can the indicator be achieved by the farmer?"
Question 3	"Are the indicator data available at the farm level?"
Question 4	"Are there any modifications or additions you would suggest for the criteria and indicators in the element air?"

After preparing the interview information form and questions, the researcher submitted the application for research ethics approval through the UiTM Research Ethics Management (UiTM RED) system and received the approval form, attached as **APPENDIX 5A**. In turn, the researcher sent an invitation letter to each expert via email to serve as stage 1 respondents. The email was accompanied by an invitation letter from the Postgraduate Studies Department, Faculty of Plantation and Agrotechnology, UiTM Jasin, Melaka, and a set of interview information and guidelines, attached as **APPENDIX 6A**. However, only 17 experts were willing to serve as respondents for stage 1, and the researcher scheduled the interview based on their availability. The researcher did not provide an honorarium to the interviewed experts.

After determining the time, the researcher conducted a pre-training interview and training on tools and software. For face-to-face interviews, a mobile phone was used to record audio; for online interviews, Google Meet was used, with video recordings. The use of recording approaches was suitable because it allowed the researcher to reach participants who may be geographically dispersed, provided flexibility in scheduling, reduced logistical barriers, and eased recording and transcription (Azad et al., 2021; Gabriel et al., 2021). The researcher also had experience with interview methods in previous studies (Anam et al., 2024). Avoiding leading follow-up questions, the researcher practised controlling the tone to a neutral level and balancing it carefully and flexibly in line with semi-structured interview guidelines (Adeoye & Olenik, 2021).

During the interview, the researcher introduced himself, acknowledged the expert, and explained the purpose of the interview. Afterwards, the researcher began recording and explained the criteria and indicators in detail to the expert. Then, the researcher asked the expert questions about the discussed criteria and indicators. However, not all criteria and indicators required expert opinions, as some experts lacked expertise in particular areas. Some experts could answer only the social dimension; some could answer both the social and economic dimensions; and some could answer only the environmental dimension. Therefore, the researcher skipped the criteria and indicators and proceeded to the criteria that the expert could answer. In addition, the average time to complete one dimension was 1 hour per person, and some could complete 2 dimensions in 1 hour and 30 minutes. This was because it depended on the expert's explanation. For dimensions that had not yet been completed, the researcher set up another interview with the expert for the second or third time.

After completing the interview with the experts, the video and audio data were saved to a Google Drive folder created for data storage. The audio data recorded via a mobile phone and Google Meet were automatically sent to the researcher's email and then transferred to this special Google Drive folder. Saving data online via Google Drive is safer and more secure than storing it on the researcher's personal computer. The consent form filled out by the experts was also placed in this folder. After saving the recorded data, the researcher conducted the data analysis as explained in section 3.5.1.4.

3.5.1.4 Step 4: Data Analysis

The data analysis was conducted using Thematic analysis (Braun & Clarke, 2006). The analysis process was prepared, and 17 interview transcripts were selected from the Google Drive folder, as shown in Figure 3.8. The process involved 6 phases; Phase one: familiarisation with the data, Phase two: generating initial codes, Phase three: generating themes, Phase four: reviewing potential themes, Phase five: defining and naming the theme, Phase six: producing the report, Phase one: familiarisation with the data, Phase two: generating initial codes, Phase three: generating themes, Phase four: reviewing potential themes, Phase five: defining and naming the theme and Phase six: producing the report. Since the analysis conserves time, the researcher used special software, such as NVivo 15 for coding and theme construction, and Audacity and Helium converter for video-to-audio conversion and merging. Turboscribe.ai used large language models to transcribe interview data: Microsoft Word and Excel for documentation. Moreover, the analysis process was modified to follow Adu's (2019)

NVivo-based approach and to align with the study's objective.

Interview data analysed using thematic analysis were used to systematically identify recurring expert opinions on criteria and indicators, relevance, feasibility, data availability, and improvement. This method is also appropriate at this stage, as it can be used across a variety of theoretical frameworks and addresses a range of research questions (Braun & Clarke, 2006; Terry et al., 2017). Organising qualitative responses into coherent themes increases transparency in the development of the sustainability index foundation, thereby enhancing the reliability, quality, and suitability of the criteria (Mothupi et al., 2020; Rezvani et al., 2017). Therefore, this method ensured that improvements to sustainability criteria were based on systematically interpreted expert knowledge.

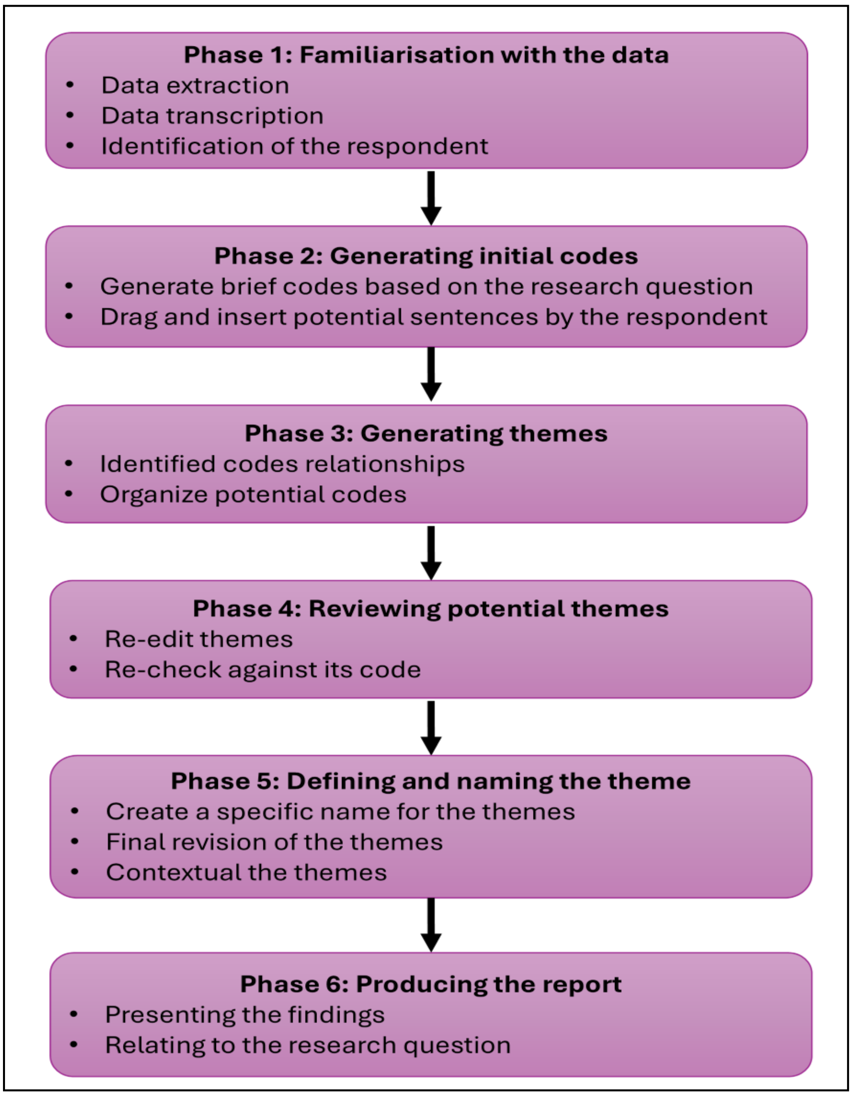


Figure 3.8 Thematic Analysis Process Adapted From (Byrne, 2022)

I. Phase 1: Familiarisation With the Data

The first phase of analysis involved downloading video and audio data from the designated Google Drive folder. The data was then converted from video (MP4) to audio (MP3) to reduce storage size using Helium Converter. Then, the audio data was transcribed into text using Large Language Model software (Turboscripe.ai). The researcher used LLM software to significantly reduce the time required for manual transcription. However, Turboscripe.ai has limitations in text-extraction accuracy. Thus, the researcher had to review the text and listen to the audio to refine the inaccurate parts. After refinement, the researcher translated the Malay text into English using Google Translate. Further, the text of each expert's response was imported into Microsoft Word for refinement. The expert identification was arranged in Microsoft Word as shown in Tables 3.3 and 3.4. Completed feedback for each respondent in Microsoft Word was exported to NVivo 15 to generate initial codes for phase two of thematic analysis. Figures 3.9 to 3.14 show the extraction, transcription, and familiarisation activity.

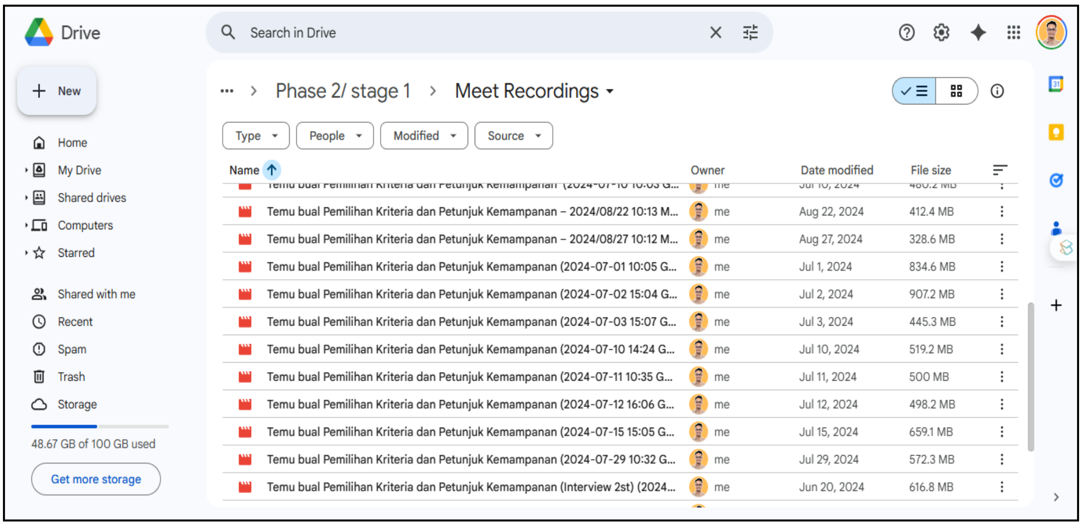


Figure 3.9 Video Extraction From Google Drive Folder

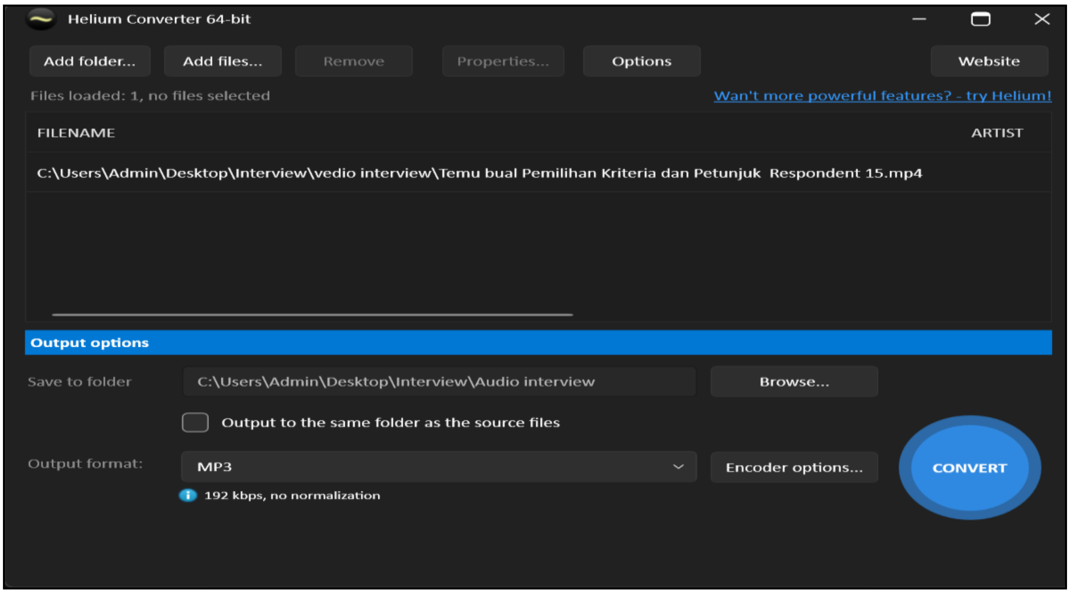


Figure 3.10 Video (MP4) to Audio (MP3) Converted

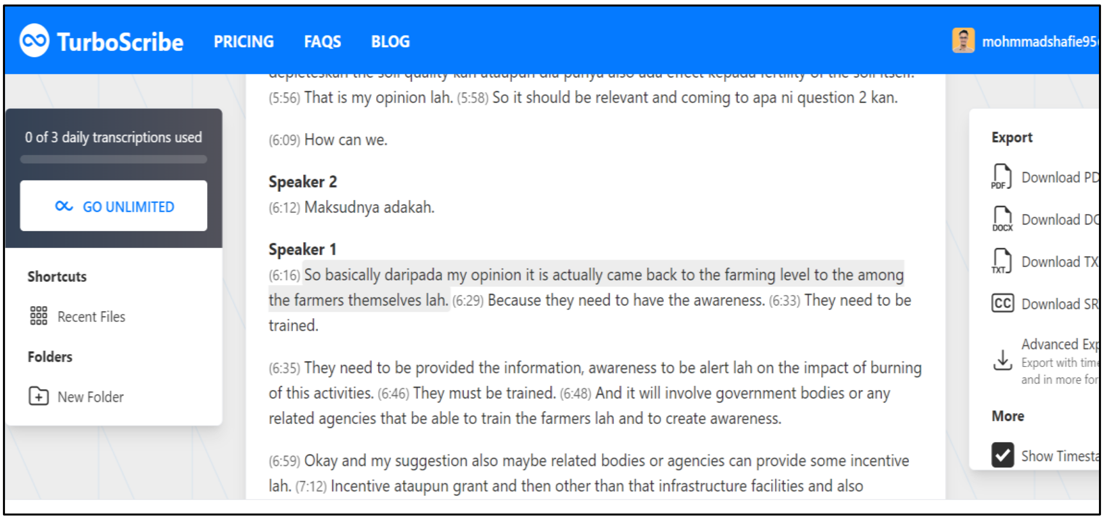


Figure 3.11 Audio Converted to Text Using Turboscript.Ai

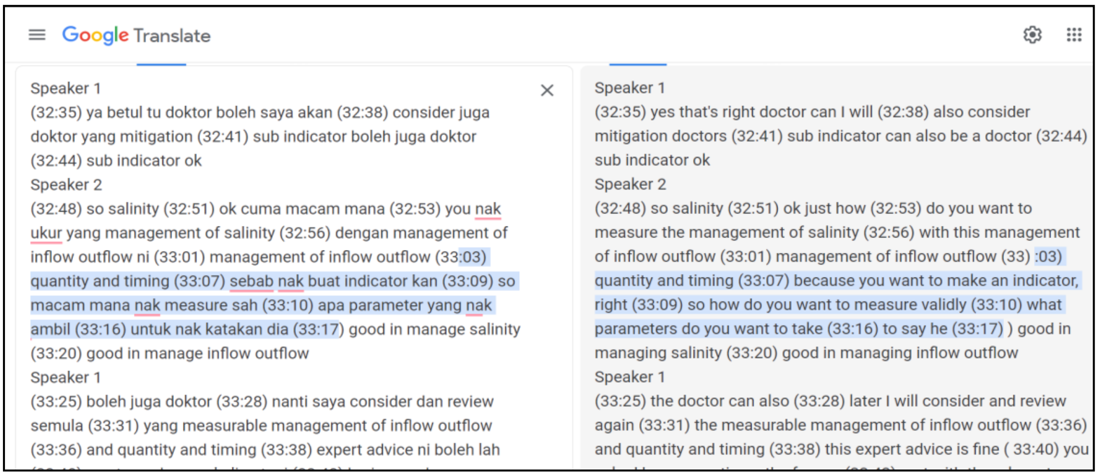


Figure 3.12 Language Translation Using Google Translate

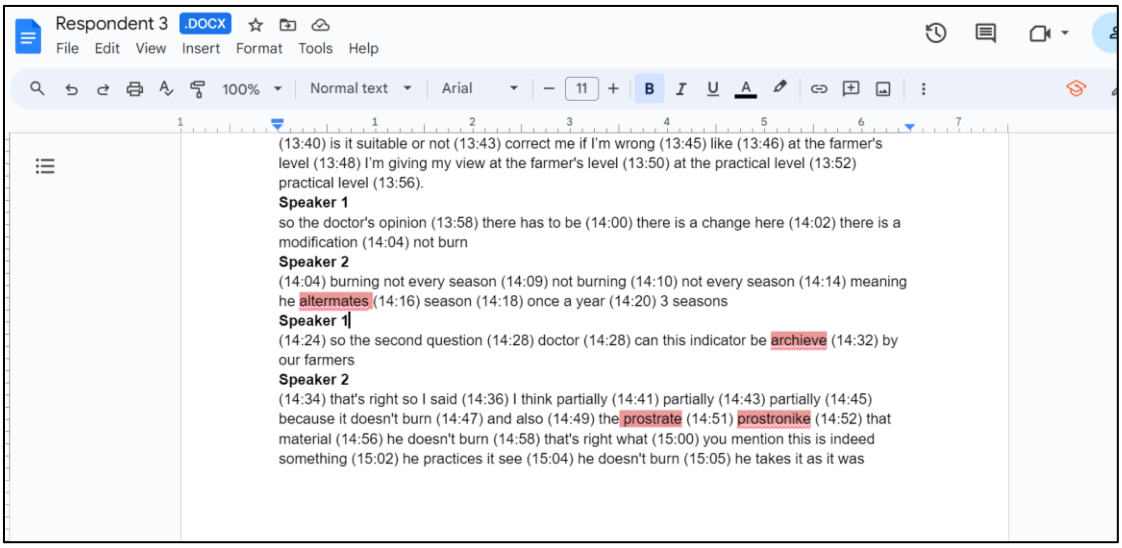


Figure 3.13 Word Correction Using Google Docs

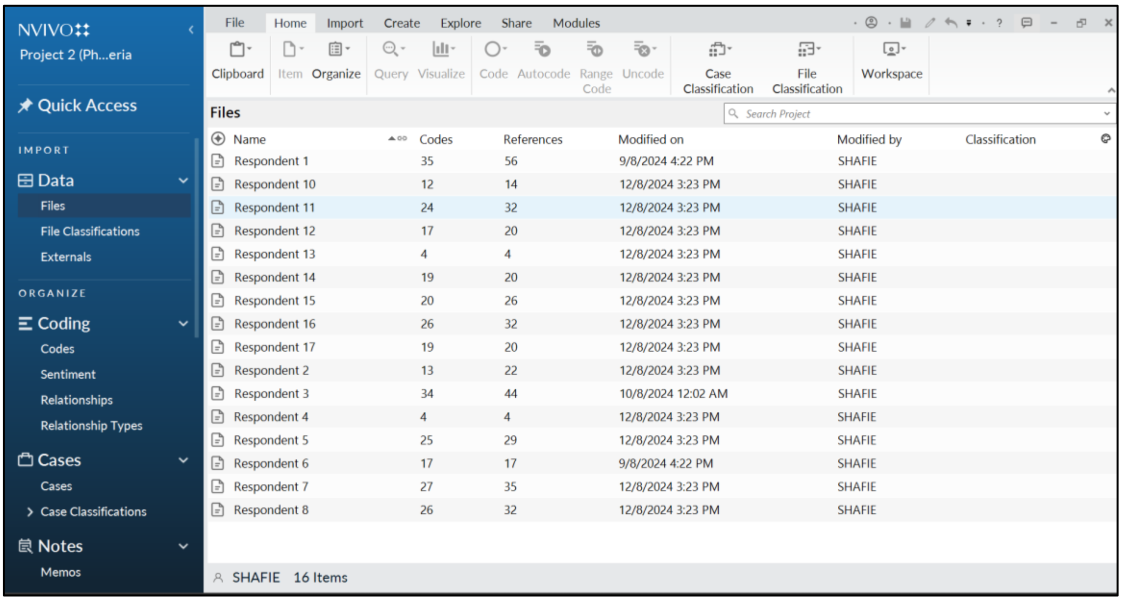


Figure 3.14 Exported Each Expert File in Nvivo V15

After performing data extraction, correction, and import of expert feedback data into NVivo 15 software. The researcher has performed expert demographic coding in NVivo 15, followed by gender and career information. Expert demographic identification information is attached in Tables 3.3 and 3.4 below.

Table 3.3
Participant Demographics and Percentages

Characteristic	N (%)
Gender	

Male	7(41)
Female	10(59)
Occupation	
Academician	12(71)
Industri expert	5(29)

Table 3.4
Occupation and Gender of Each Participant

Expert	Occupation	Gender
Expert 1	Academia	Male
Expert 2	Academia	Female
Expert 3	Academia	Female
Expert 4	Academia	Female
Expert 5	Industri expert	Female
Expert 6	Industri expert	Male
Expert 7	Industri expert	Female
Expert 8	Industri expert	Male
Expert 9	Academia	Female
Expert 10	Academia	Female
Expert 11	Academia	Female
Expert 12	Academia	Female
Expert 13	Academia	Male
Expert 14	Academia	Male
Expert 15	Academia	Male
Expert 16	Industri expert	Male
Expert 17	Academia	Female

II. Phase 2: Generating Initial Codes

At this stage, the researcher reviews each respondent's file and codes relevant segments under their respective research questions. The researcher uses NVivo version 15 software to create a node (which can be viewed as a container) (Adu, 2019; Bazeley & Jackson, 2014). The researcher used the coding strategy ‘interpretation-focused coding’ to analyse the interview transcripts (Adu, 2019). The researcher also assigned initial labels (initial anchor codes) to the research question, as shown in Figure 3.15. Generating anchor codes to help organise the codes/nodes under each of the research questions (Adu, 2019). Below are the research questions and their anchor codes:

1. How do the proposed criteria and indicators align with the local context at the farm level in Malaysia? ***(Contextual Relevance)***
2. Can the indicator be achieved by the farmer? ***(Practical Application)***
3. Are the indicator data available at the farm level? ***(Data availability)***
4. Are there any modifications or additions you would suggest for the criteria and indicators in the element air? ***(Modification or additions)***

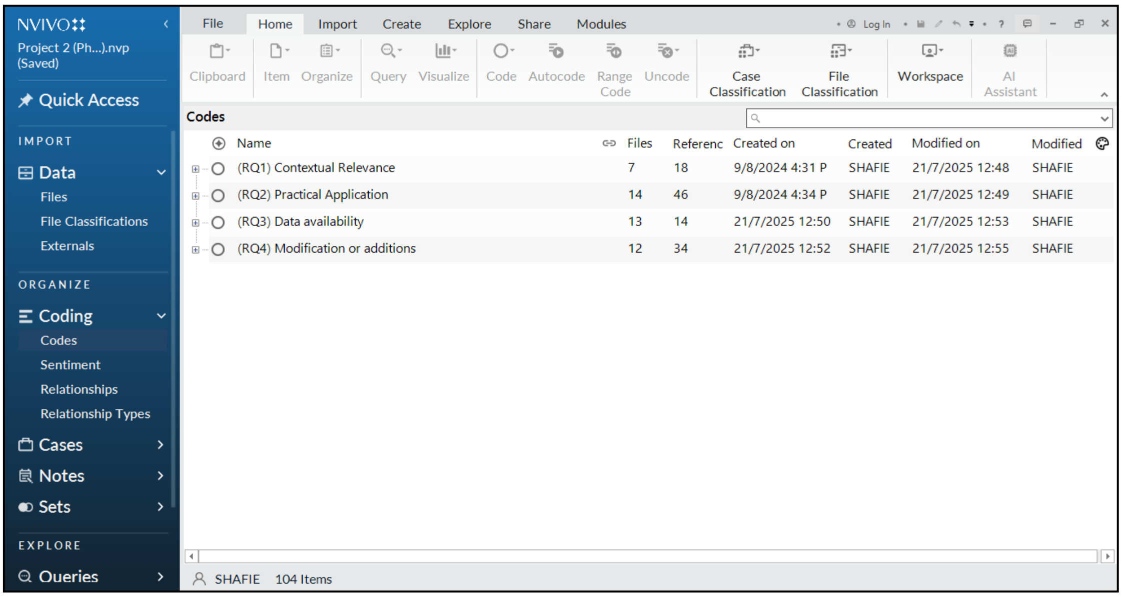


Figure 3.15 Anchor Code

After generating the anchor code, the researcher reviews the respondent text to develop the initial code. The researcher generated 3-5 words for each initial code directly in NVivo 15 software, as shown in Figure 3.16. The highlighted sentences were dragged into the generated initial code.

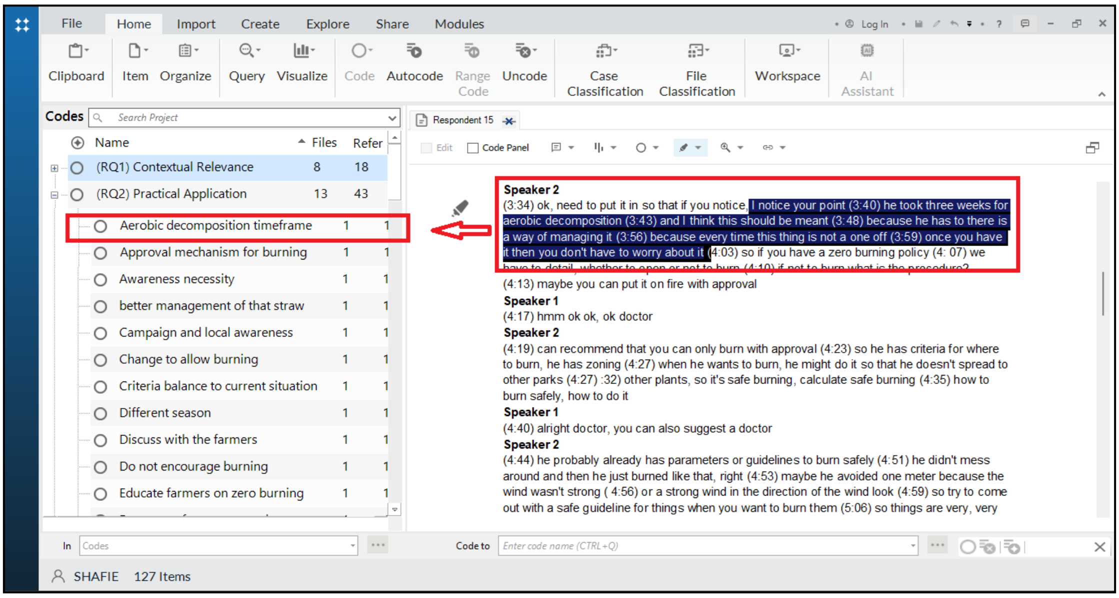


Figure 3.16 Generated Initial Code

III. Phase 3: Generating Themes

The phase begins after all relevant data items have been coded. The phases shift from interpreting individual data items within the dataset to interpreting aggregated meaning and meaningfulness across the dataset (Byrne, 2022). The coded data were reviewed and analysed to determine how different codes may be combined according to shared meanings, forming themes, codes, or sub-codes. The process of generating themes and classification of the code was conducted using Microsoft Word, Excel, and NVivo 15. The sorting strategies were individual, adapted from Adu (2019). Figure 3.17 shows the sorting process. Moreover, the individual sorting strategies process will continue until Phase Five due to the interview analysis flow thematic analysis process (Braun & Clarke, 2006).

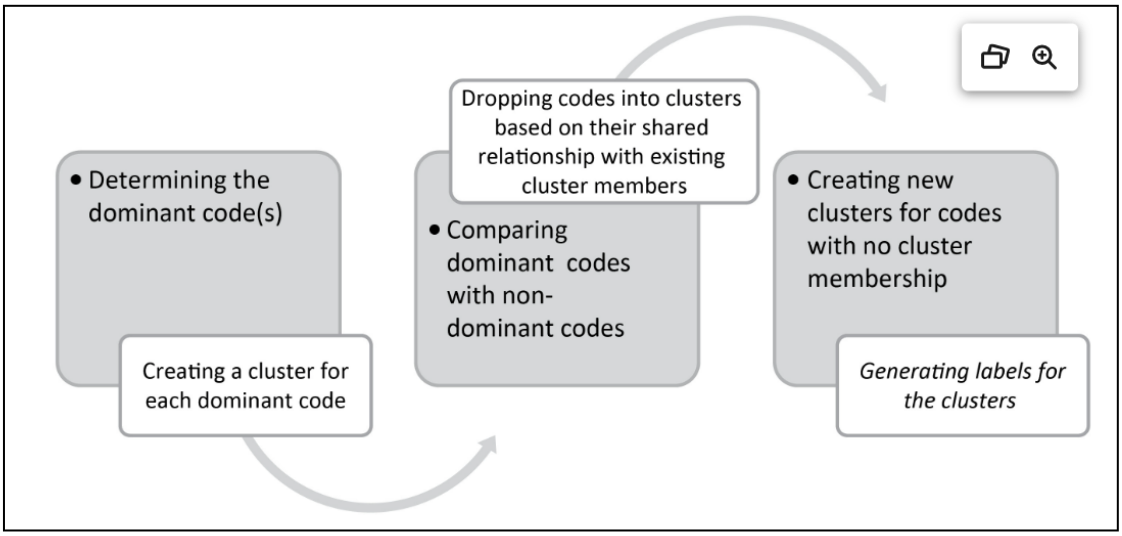


Figure 3.17 Individual Sorting Strategies Process Adapted From (Adu, 2019)

This phase used Microsoft Excel and Word for individual sorting strategies. The first step was to determine the dominant codes and compare them with the non-dominant codes. The NVivo 15 code list was imported into an Excel file, with the file and reference counts under the research question. Then, coded had the highest file and reference counts, making it the dominant code. Figure 3.18 shows the dominant code determination under the research question "How do the proposed criteria and indicators align with the local context at the farm level in Malaysia? ***(Contextual Relevance)***". The process continued following other criteria and indicator questions. The other sustainability criteria and indicators questions were skipped in the thematic analysis of phases 3 and 4 using NVivo to reduce the flooding of analysis data. Instead, thematic analysis started at phase 5, shown in **APPENDIX 7A**.

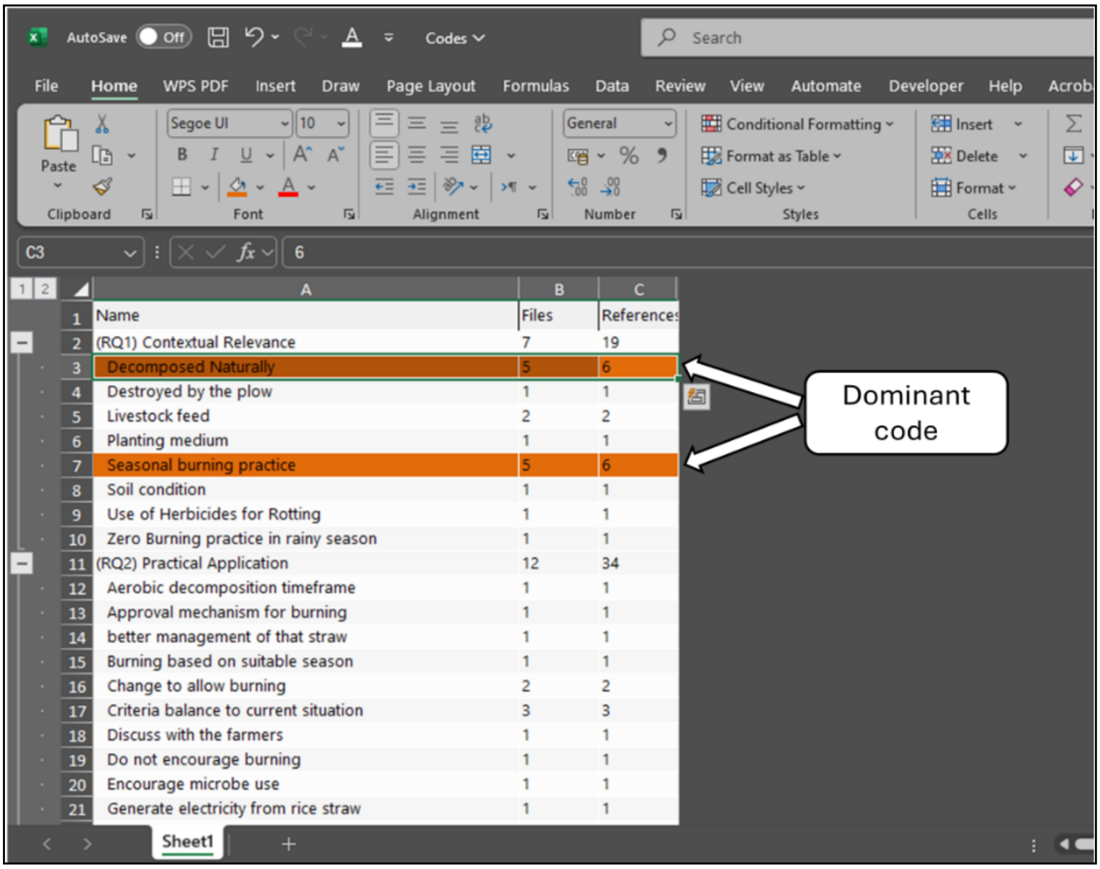


Figure 3.18 The Dominant Code Under (RQ1 Contextually Relevant)

Further, in the second step, the researcher creates a cluster table with a label and its frequency. Then place the dominant code in a cluster table in Microsoft Word, as shown in Figure 3.19.

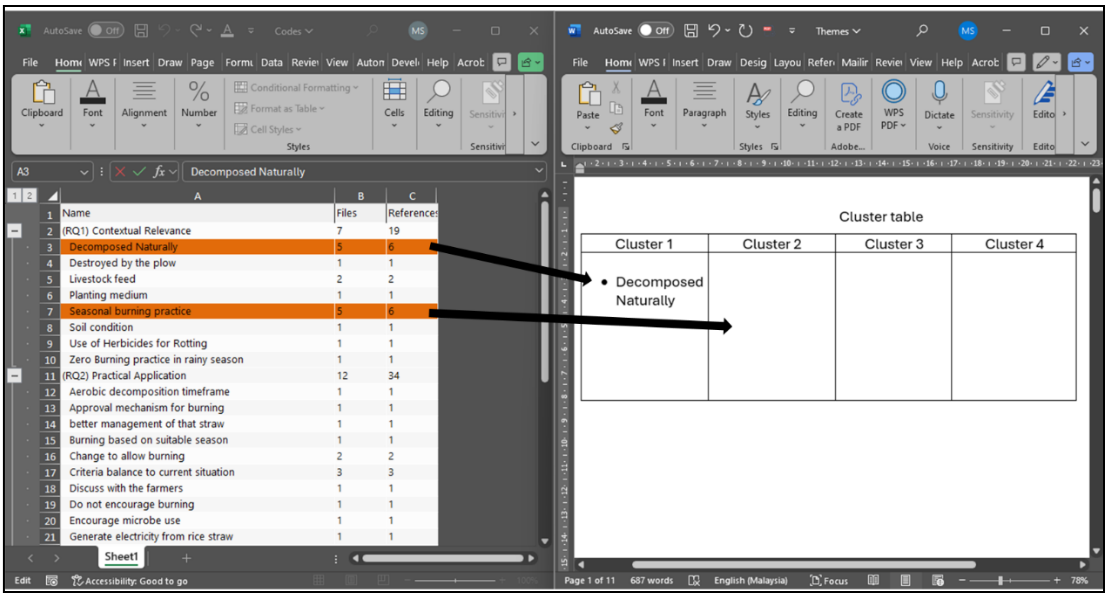


Figure 3.19 Transfer of Dominant Code in The Cluster Table

In the third step, the researcher starts to review the characteristics of each code by looking at their descriptions and some of the empirical indicators connected to them, comparing them to the dominant code to determine their shared relationships, and dropping the codes into the cluster with the dominant code if they have things in common. Table 3.5 shows the initial cluster table.

Table 3.5
The Initial Cluster Table

Cluster 1	**Cluster 2**	**Cluster 3**
• Decomposed Naturally (5 count) • Livestock feed (1 count) • Destroyed by the plough (1 count)	• Seasonal burning practice (5 counts) • Soil condition (1 count) • Planting medium	• Livestock feed (2 counts • Use of Herbicides for Rotting (1 count) • Zero Burning practice in rainy season (1 count)

IV. Phase 4: Reviewing Potential Themes

Continue with step 3 of individual sorting strategies for phase four of thematic analysis. The researcher reviewed the members in each cluster to ensure each code was assigned to the appropriate cluster. The researcher may now keep themes, create new themes, reject themes, and change which codes are included in which themes (Braun & Clarke, 2006). Table 3.6 shows the reviewed cluster table.

Table 3.6
The Reviewed Potential Theme for The Cluster Table

Theme (*Decomposition*)	Theme (*Cluster 2*)	Theme (*By-product*)
● Decomposed Naturally (5 counts) ● Soil condition (1 count) ● Use of microbe for rotting (1 count)	● Destroyed by the Plough (1 count) ● Seasonal burning practice (5 counts)	● Livestock feed (2 counts ● Planting Medium (1 count) ● Zero Burning practice in rainy season (1 count))

V. **Phase 5: Defining and Naming the Theme**

Continue with step 3 of individual sorting strategies (Label the theme) for phase 5 of the thematic analysis. The research aimed to determine the basic meaning of each topic and the overall meaning of the themes (Braun & Clarke, 2006). This was performed by the researcher, who re-reads the subsumed data excerpts and creates a cohesive narrative explanation of their contents. The researcher identified suitable themes and assigned each a code, as shown in Table 3.7, along with its name.

Table 3.7
The Finalised Name of the Theme in Each Cluster

Theme (*Natural Decomposition*)	Theme (*Agricultural Practices*)	Theme (*Resource Utilisation*)
● Decomposed Naturally (3 counts) ● Use of microbe for rotting (3 counts) ● Soil condition (1 count)	● Destroyed by the Plough (1 count) ● Seasonal burning practice (5 counts)	● Livestock feed (2 counts ● Planting Medium (1 count) ● Zero Burning practice in rainy season (1 count)

The definition of each finalised theme is based on its relationship with code, as shown below:

- Theme (Natural Decomposition): Ecological process that can be harnessed to manage agricultural waste and promote sustainable farming practices.
- Theme (Agricultural Practices): Methods and techniques employed by farmers to handle and dispose of crop residues after harvest.

- (Resource Utilisation): Sustainable practice that can contribute to a more circular agricultural economy.

VI. Phase 6: Producing the report.

In this phase, the researcher presented the findings from the interview analysis. The presentation of the findings used an individualised theme-driven format) (Adu, 2019). The analysis of "(RQ1) Contextually Relevant" shows that three practices align with the proposed Zero-burning criteria: Natural Decomposition, Agricultural Practices, and Resource Utilisation, as shown in Table 3.8. The findings detail all the proposed criteria and indicators presented in **APPENDIX 8A.**

Table 3.8
Themes and its Features Under "(RQ1) Contextual Relevant"

Themes	**Description**	**No of participants**	**No of empirical indicators**	**Empirical indicator**
Natural Decomposition	Ecological processes that can be harnessed to manage agricultural waste and promote sustainable farming practices	6	8	*.....Sometimes the hay doesn't have time to burn. It will do it himself, he will do what he calls it, he will destroy himself like that….farmer left it, in the rainy season, there is a lot of water. Let it rot, you know? Rotting. He let it touch the water, sour. Expert 2*
Agricultural Practices	Methods and techniques employed by farmers to handle and dispose of crop residues after harvest	6	7	*….I think he is relevant if the zero burning practice takes place in rainy season because most farmers finish their harvest, after that harvesting period they will use it for the next season, they want to wait for the next season, they will burn it first…Expert 5*
Resource Utilization	Sustainable practice that can contribute to a more circular agricultural economy	2	3	*.....Used for livestock food consumption… Expertt 7 and 8*

Refining the proposed sustainability criteria based on interview findings was important in forming content validity and contextual relevance. Thematic analysis based on interview findings was a systematic, interpretive approach that used expert judgment to assess relevance, feasibility, clarity, and data availability, and that could be synthesised transparently. Continuity between the interview findings and the criteria improvement was achieved through the thematic analysis, in which emergent themes were mapped to refinement actions. Themes that met the stated criteria but did not conceptually align with rice or sustainability were eliminated; themes that highlighted practical relevance and aligned with rice cultivation were considered, while themes that made suggestions were also considered in changing the criteria and indicators. Further, the experts' majority agreement was also considered in determining whether to include or combine, while low agreement was considered before exclusion.

The finalised sustainability criteria were driven by systematically interpreted expert consensus and reduced reliance on researcher judgment. Thus, the transparency theme identified through thematic analysis further strengthens the traceability and credibility of the refinement process. The sustainability criteria from phases 1 and 2 described the validation pathway, starting with the establishment of a theoretical framework based on a recognised sustainability framework and progressing to expert judgment, are contextually validated. Therefore, the stage was content valid, contextually relevant, and measurable, focusing on rice cultivation at the farm level and suitable for use in index development.

3.5.1.5 Step 5: Criteria and Indicator Improvement

Data analysis to obtain expert opinions on the proposed criteria and indicators has yielded brief findings on whether to improve or retain them. Based on the analysis report, the researcher has made improvements and additions to the criteria and indicator descriptions. Table 3.9 shows the proposed criteria for zero-burning practices and indicators, with their descriptions and colour-coded highlights for improvement.

Table 3.9
The Proposed Criteria and Description for Improvement

Environmental Dimension
[Element: Air] Criteria 1: Zero burning practices This criterion aims to ensure that no fire is used for the disposal of waste at any stage of rice cultivation and farm operations unless permitted by the relevant state authorities. Rice residue burning is controlled only if there are disease problems and severe wind rice infestation in the previous season. Indicator 1: Rice Stubble Rice stubble is managed sustainably to mitigate greenhouse gas emissions, minimise environmental impacts, and retain or improve soil quality. Rice stubble is: • Not Burned. • Allowed sufficient time (at least 3 weeks) for aerobic decomposition before wetting. • Burning is controlled only if there are disease problems and severe wind rice infestation in the previous season. Indicator 2: Rice Straw Rice straw is managed sustainably to mitigate greenhouse gas emissions, minimise environmental impacts, and retain or improve soil quality. Rice straw is: • Not burned. • Allowed sufficient time (at least 2 weeks) for aerobic decomposition if rice straw is left on the field or ploughed under. • Collected, sufficient time (at least 2 weeks) for aerobic decomposition if rice straw is left on the field or ploughed under. • Rice straw decaying material or agent using microbes is encouraged to help speed up the decay of straw into organic material. The decay of straw can return nutrients to the soil and contribute to increasing soil fertility. • Burning is controlled only if there are disease problems and severe wind rice infestation in the previous season.

The researcher has improved and maintained the description of the proposed criteria based on the reported analysis results. The items that have been changed are highlighted in green or *italic* as attached in Table 3.10 below.

Table 3.10
The Improvement Criteria and Their Descriptions

Environmental Dimension
[Element: Air] Criteria 1: Zero burning practices This criterion aims to ensure that rice farmers are encouraged not to burn their rice residue openly throughout all stages of rice cultivation and operation at the farm level unless permitted by relevant local authorities. The farmer encourages sustainable rice residue practices. Indicator 1: Rice Stubble

Rice stubble is managed sustainably to minimise greenhouse gas emissions and environmental impacts while retaining soil quality. Rice stubble is:

- *Controlled burning is allowed for rice stubble, but mandatory to follow the Malaysia Environmental Quality Act 1974 [127 ACT] (Declared Activities) (Open Burning) 2003.*
- *Farmers should use decaying material (micro agent) if the stubble is not burned.*
- *Farmers are allowed to plough under the empty rice field to thresh the rice stubble in the field without using decaying material (micro agent), by-product usage, or burning to decompose naturally during a continuous wet situation (Such as a Rainy Day).*

Indicator 2: Rice Straw
Rice straw is managed sustainably to mitigate greenhouse gas emissions, minimise environmental impacts, and retain or improve soil quality. Rice straw is:

- *Controlled burning is allowed for the rice straw, but mandatory to follow the Malaysia Environmental Quality Act 1974 [127 ACT] (Declared Activities) (Open Burning) 2003.*
- *Farmers should collect rice straw for by-product usage.*
- *If the straw is not used as a by-product or burned, the farmer should use decaying material (micro agent).*
- *Farmers can plough under the empty rice field to thresh the rice straw in the field without using decaying material (micro agent), by-product usage, or burning, allowing it to decompose naturally in a continuous wet situation (Such as a Rainy Day).*

3.5.1.6 Credibility of The Analysis Process and Findings

In qualitative research, it is essential to ensure credibility. Promoting credibility involves systematically drawing findings from appropriately collected data and presenting them with supporting evidence (Cho & Trent, 2006). Therefore, researchers have ensured the credibility of their research by following three strategies: consistency, systematicity, and transparency (Adu, 2019). Ensuring consistency involves taking actions and making decisions about data analysis that align with the philosophical paradigm, associated assumptions, and research method you have chosen (Greckhamer & Cilesiz, 2014). The researcher chose a qualitative method, using semi-structured interviews, and detailed the data collection process and applied thematic analysis. This selection was based on the research objective that the researcher wanted to achieve. Furthermore, to ensure that the qualitative approach used was systematic. The researcher followed the chosen steps to obtain, analyse, and explain the data in detail. Based on the analysis method, the researcher explained how to create coding, themes, and finalised themes. In addition, the researcher used NVivo 15 to extract and analyse data.

Furthermore, transparency focuses on bringing to light your private and subjective experience of the qualitative analysis process (Greckhamer & Cilesiz, 2014). The researcher has documented the activities carried out during the analysis, including changing the analysis method to align with the study's objective and noting the shortcomings of using Artificial Intelligence software for data translation. Sharing all this behind-the-scenes documentation "...enables readers to evaluate a study's rigour and the trustworthiness of its results" (Greckhamer & Cilesiz, 2014).

3.5.2 Stage 2: Qualitative Review of Measurable Sub-Indicator

In this stage, a literature review was conducted. A narrative literature review type, modified by the researcher, was used in this stage. The researcher recognised the limitations of narrative literature reviews, as they often lack methodological transparency, credibility, and pragmatism (Juntunen & Lehenkari, 2021; Pittman, 2023) in contrast to a systematic literature review, which closely follows scientific procedure to limit systematic error by synthesising relevant literature to answer a set of questions (Petticrew & Roberts, 2006). The objective of this stage is to identify and finalise suitable sub-indicators based on the finalised sustainability criteria and indicators from stage 1. Sub-indicators are measurable variables used to quantify the sustainability of rice-farmer practices.

This stage focuses solely on extracting and developing sub-indicators from existing studies and sustainability frameworks, rather than producing primary empirical findings. These sub-indicators represent operational measurement variables derived from the refined framework and align with those of past studies to ensure they remain grounded. Therefore, selecting a narrative literature review as the stage 2 method ensures that these sub-indicators remain aligned with the finalised criteria from stage 1, rather than using methods such as systematic literature review (SLR), which is more comprehensive and requires the PRISMA approach (Synder, 2019). In addition, the findings of this SLR approach are based on a review of past studies, especially academic articles; not all the sub-indicators obtained are suitable for direct adaptation into the sustainability index assessment. This is because focusing on lower-level assessments, such as the farm level, affects the data that needs to be collected. Most indicators are limited by the availability of relevant and reliable data, leading to the selection of indicators based on existing data rather than on suitable indicators (Moldan & Dahl, 2007). Thus, narrative approaches were suitable for ensuring these stages maintain a scientific and systematic approach, further increasing the transparency and validity of the index procedures. The review procedure was 1) literature search, 2) adaptation and questionnaire development, and 3) content validation, modified from (Ferrari, 2015).

3.5.2.1 Literature Search

The first procedure was a literature search conducted straightforwardly in the search engine “Google Scholar”. The Google Scholar academic search engine is a tool for searching relevant research articles and literature (Juntunen & Lehenkari, 2021). The database enhances ease of use by offering a quick, convenient overview of scholarly publications (Jensenius et al., 2018). Furthermore, it provides a simple approach for broadly searching for scholarly literature across multiple disciplines and sources (Mikki, 2009; Martin et al., 2018). Google Scholar was a reasonable choice for its broad interdisciplinary coverage of articles, technical reports, and policy-relevant publications, which is well-suited to sustainability research across environmental, economic, and social dimensions. The purpose of the search was to identify measurable variables rather than to conduct an exhaustive systematic synthesis, and multiple academic databases were not the focus of this stage. Instead, focus on relevance, aligned concepts, and applicable measures at the farm level. The search covered the open period through the end of the year 2024.

The finalised indicator from phase 2 of stage 1 was used as the search terms of the literature search. The terms were: “rice stubble and straw”, “water management”, “land suitability”, “land preparation”, “timing of harvest”, “harvest equipment”, “post-harvesting handling”, “non-renewable energy consumption”, “mechanism action reducing non-renewable energy consumption”, “management plan”, “ farm operational disposal”, “Pure quality seeds”, “Chemical pesticide”, “Biological control pest”, “Inorganic and organic fertilizer”, “Organic fertilizer”, “Integrated Pest Management (IPM)”, “Record keeping”, “Guarantee of production levels”, “Procurement Channels/ Input Supplies”, “Net Cash Flow”, “Safety Nets”, “Fiscal Commitment”, “Right to Quality of Life”, “Capacity Development”, “Proof of ownership”, “Employment relations”, “Force labour”, “Discrimination”, “Child labour”, “Wages”, “Freedom of Association”, “Safety Instruction and first aid”, “Tools and equipment”, “Training of pesticide applicators”, “Personal protective equipment (PPE)”, “Washing and changing”, “Applicator restrictions”, and “Re-entry time”.

The inclusion of literature based on sub-indicators in the agriculture sector and on rice, and the relevance for measurement. Exclusion of literature based on different intents of the finalised criteria and the main indicator. However, most of the identified literature sub-indicators were unsuitable for assessment in rice cultivation because they did not align with the finalised criteria and were eliminated after reviewing the methodology section. Thus, a broad body of literature aligned with the criteria and the main indicator's intent for sub-indicator adaptations.

3.5.2.2 Adaptation and Questionnaire Development

The researcher has adapted the sub-indicators and their questions to align with the finalised criteria and indicators. Meanwhile, for sub-indicators that do not meet the criteria and the indicators' description, the researcher has adapted them based on the selected sustainability framework and the Malaysian Rice Check Guideline, creating new sub-indicator names and new questions from the document. The mapping of the sub-indicator adaptation and development is presented in **APPENDIX 9A**. One of the measurable indicators adapted from the literature search was the “amount of chemical pesticides in litres/year”. However, unfound sub-indicators were taken from the Sustainable Rice Platform Standard: Burning, By-product use, Decaying material use, Use of plough for rice straw, and rice stubble. The description of rice stubble in the Sustainable Rice Platform, which is also incorporated into the sustainability criteria framework of this study, serves as the basis for developing a questionnaire for use in the survey session with rice farmers. The questionnaire for each sub-indicator was designed as a closed-ended survey for farmers (Aithal & Aithal, 2020; Taherdoost, 2022). Before the sub-indicator questionnaire was validated by an expert in the next sub-section, 3.5.2.3, the researcher's supervisor rechecked the questionnaire to ensure there was no redundancy and that no open-ended questions were included.

3.5.2.3 Content Validity Index

Before finalising the questionnaires and indicators, the researcher did content validation (Aithal & Aithal, 2020; Yusoff, 2019). Content validation adapted six (6) steps: a) preparing the form, b) selecting experts, c) conducting content validation, d) reviewing domain and items, e) Scoring items, and f) CVI calculation (Yusoff, 2019). Content validity of the sub-indicators and questionnaires was assessed before the assessment to ensure data availability and the reliability of the sustainability index. Conducting content validity assessment is the initial and necessary step in the development of measurement procedures, ensuring that the results are reliable (Ibiyemi et al., 2019). Linking abstract concepts to measurable indicators before data collection (Anuar et al., 2024). Content validity is also a critical initial step in enhancing construct validity, which is important in developing high-quality measurement (Polit et al., 2007). The content validation was conducted two (2) times to finalise the sub-indicator with its questionnaire. Detailed steps are presented below:

a) *Preparing forms*. The researcher has prepared a content validation form for the panel to get an overview and understanding. State the description of the validation, sub-indicator, questionnaire, and rating scale that were used for the scoring of individual items, as shown in Figure 3.23. This validation form has been submitted via Google Forms to facilitate the collection of validation data.
b) *Selecting an expert*. The expert was selected based on their expertise in sustainability and rice cultivation. The expert was selected from previous interviews on finalised sustainability criteria or frameworks. The recommended number of expert samples was five (5) to eight (8) (Yusoff, 2019). However, only two (2) experts accepted the task for the content validation. These two (2) experts adhered to the minimum acceptable standard for experts (Davis, 1992). Furthermore, both experts possessed relevant expertise in agricultural and rice sustainability, which aligned with the objective of this research. The stage focused on the relevance and suitability of the sub-indicator and questionnaire rather than achieving statistical generalisation.
c) *Conducted content validation*. This approach involved using an online content validation form via Google Forms, with clear instructions provided to the expert. The researcher used Google Forms to reduce cost and conserve expert time (Yusoff, 2019).
d) *Reviewing the domain and items*. The researcher clearly presents the domain definition and the items provided to the expert, as shown in Figure 3.23. In addition, the domain and the items were reviewed by the researcher's second co-supervisor before the form was sent. The expert also requested a review, a score, and a written comment in the provided fill-in box. Their writing has also been considered for finalising the sub-indicator.

e) Scoring items. After being instructed to review domains and items, experts must independently score the relevant item scale. The experts must submit their answers after they have finished scoring all the items.
f) *CVI calculation*. After receiving the responses, the researcher calculated a CVI. There are two forms of CVI: (I-CVI) for the item and (S-CVI) for the scale. In S-CVI, there are two calculations: the average I-CVI score for all items on the scale (S-CVI/Average) and the percentage of items in the scale that are rated as usefulness level 3 or 4 by all experts (S-CVI/UA). The formulae and definitions of the CVI indices are shown in Table 3.11 (Davis, 1992; Polit & Beck, 2006; Yusoff, 2019).

Table 3.11
Formula and Definition of S-CVI/UA, I-CVI and S-CVI/AVE

CVI indices	**Formula**	**Definition**
S-CVI/UA	S-CVI/Average= Sum of UA scores/ number of items	The percentage of items in the scale that received a 3 or 4 from all experts. The Universal Agreement (UA) score is set to 1 if the item received 100% agreement from experts. Otherwise, the UA score is 0.
I-CVI	I-CVI= agreed item/ number of experts	S-CVI/average is calculated by taking the average value of I-CVI for all items. Each I-CVI is determined by averaging the relevance assessments of each expert for that item.
S-CVI/Average	S-CVI/UA= Sum of UA scores/ number of items S-CVI/Average = Sum of I-CVI scores/ number of items	The average I-CVI score for all items in the scale is the average proportion of experts who considered each item relevant. The proportion of items considered relevant is determined by the average relevance rating per expert.

Before the Content Validity Index calculation, the relevant rating was assigned by converting a score of 3 or 4 to 1 (relevance) and a score of 1 or 2 to 0 (irrelevance) for each expert's feedback, as shown in Table 3.12. On the other hand, the I-CVI for each item was calculated based on the expert's relevance rating, as shown in Table 3.11. The findings showed that the I-CVI values for most items were high, exceeding the accepted threshold (>0.80), indicating full agreement between the two experts on the items' relevance. However, the S-CVI/UA values were below the recommended threshold, indicating that not all items reached agreement. Thus, one round of validation was conducted with the same expert, focusing on the items developed from the finalised criteria, as they were aligned with their intent. The results of the second round of validation were used to finalise the assessment items for the rice farmer. The verification results are attached. **APPENDIX 10A**.

Table 3.12
Experts' Relevant Rating on The Item Scale

Item	Expert 1	Expert 2	Expert in agreement	I-CVI	UA
Q1	1	1	2	1	1
Q2	0	1	1	0.5	0
Q3	1	1	2	1	1
Q4	1	1	2	1	1
Q5	1	1	2	1	1
Q6	1	0	1	0.5	0
Q7	1	1	2	1	1
Q8	1	1	2	1	1
Q9	1	1	2	1	1
Q10	0	1	1	0.5	0
Q11	1	1	2	1	1
Q12	1	0	1	0.5	0
Q13	1	0	1	0.67	0
Q14	1	1	2	1	1
Q15	0	1	1	0.5	0
Q16	0	0	0	0.5	0
Q17	0	0	0	0.5	0
Q18	0	0	0	0.5	0
Q19	0	0	0	0.5	0
Q20	0	0	0	0.5	0
Q21	0	0	0	0.5	0
Q22	0	0	0	0.5	0
Q23	1	1	2	1	1
Q24	1	1	2	1	1
Q25	1	1	2	1	1
Q26	1	1	2	1	1
Q27	1	0	1	0.5	0
Q28	1	1	2	1	1
Q29	1	1	2	1	1
Q30	1	1	2	1	1
Q31	1	1	2	1	1
Q32	1	1	2	1	1
Q33	1	1	2	1	1
Q34	1	0	1	0.5	0
Q35	1	1	2	1	1
Q36	1	1	2	1	1
Q37	1	1	2	1	1
Q38	1	1	2	1	1
Q39	1	1	2	1	1
Q40	1	1	2	1	1

Q41	1	1		2	1	1
Q42	1	1		2	1	1
Q43	1	1		2	1	1
Q44	1	1		2	1	1
Q45	1	0		1	0.5	0
Q46	1	1		2	1	1
Q47	1	1		2	1	1
Q48	1	1		2	1	1
Q49	1	1		2	1	1
Q50	1	1		2	1	1
Q51	1	1		2	1	1
Q52	0	1		1	0.5	0
Q53	0	0		0	0.5	0
Q54	0	0		0	0.5	0
Q55	0	1		1	0.5	0
Q56	0	1		1	0.5	0
Q57	1	1		2	1	1
Q58	1	1		2	1	1
Q59	1	1		2	1	1
Q60	1	1		2	1	1
Q61	1	0		1	0.5	0
Q62	0	0		0	0	0
Q63	1	1		2	1	1
				S-CVI/Ave	1.48	
				S-CVI/UA		0.63
Proportion relevant	0.75	0.73				
Average proportion			0.74			

3.6 Phase 3: Assessment and Development of The Sustainability Index

Phase 3 has focused on the empirical assessment of rice farmers' cultivation practices and the development of the Malaysia Sustainable Rice Index (MySRI). This phase, in parallel with the research objective, aimed to assess the sustainability performance of rice farmers' cultivation practices and to construct a sustainability index using mathematical algorithms. The empirical assessment was conducted before index construction to obtain raw, measurable farm-level sustainability data that were used for index calculation and sustainability performance evaluation. Therefore, this phase has operationalised the validated sustainability criteria, indicators, and sub-indicators established in Phases 1 and 2 into measurable sustainability assessment components suitable for rice farm assessment in Malaysia.

A quantitative approach has been adopted to enable the systematic collection, standardisation, and analysis of sustainability data from rice farmers. The assessment data were integrated into the index development procedure, including data preparation, normalisation, weighting, aggregation, and result interpretation. This procedure was important for converting raw assessment data into interpretable sustainability performance scores across environmental, economic, and social dimensions. The index requires that assessment data, including indicators, benchmarks, and weights, be collected after selecting relevant indicators and assessing their positive or negative impacts on sustainable development during the modelling stage (Zhou et al., 2012).

Ensuring methodological transparency and replicability, the development of the index has followed predefined and systematically documented procedures consisting of sustainability assessment, data transformation, normalisation, weighting, aggregation and result interpretation. Various index developers conduct pre-assessment before index assessment, such as Chand et al. (2015), Talukder et al. (2017), and Valizadeh & Hayati (2021). Therefore, Phase 3 acted as empirical assessment and operational index development for translated sustainability practice among rice farmers into measurable sustainability performance output through the Malaysia Sustainable Rice Index (MySRI).

3.6.1 Assessment of Sustainability Practices

A quantitative approach has been adapted to this empirical assessment to evaluate the sustainability practices of rice farmers based on validated sustainability criteria, indicators, and sub-indicators established in previous phases. Therefore, a face-to-face survey approach was adapted (Grontkowska et al., 2020; Roesch et al., 2021). The empirical assessment aligned with the third objective by generating measurable farm-level data required for index construction. A survey was used to assess because cost-effective approach for obtaining data to set research priorities and design intervention strategies to improve farmer practices (Escalada et al., 1997).

Additionally, sustainability assessment at the farm level was limited by the availability of secondary data, farm documentation, and record-keeping practices. Most indicators from the social dimension are qualitative, difficult to quantify, and subjective (Latruffe et al., 2016). It is necessary to develop indicators, such as those in phase 2, that can be quantified using survey approaches. In addition, rice farmers' record-keeping practices are less emphasised because they are time-consuming and burdensome (Mohd Arifin et al., 2024). This results in limited data availability, requiring a survey-based approach to data collection. Data availability is often a limiting factor when selecting farm-level sustainability indicators to track progress and guide decisions (Robling et al., 2023). Therefore, this method provided a practical, systematic way to obtain directly measurable sustainability assessment data from rice farmers in this research context.

Furthermore, this method has also enabled empirical assessment data to be standardised, compared, transformed and integrated into the index development procedure. This is important because empirical data collected via questionnaires or secondary data are in accordance with the index procedure, which involves normalisation, weighting, and aggregation techniques (Talukder et al., 2017). On the other hand, the sustainability indicator has various units of measurement that are taken from primary data such as surveys or secondary data, therefore influencing component index algorithms such as normalisation (Romanov et al., 2025). In essence, the quantitative survey approach was considered suitable for enabling farm-level sustainability assessment and operational sustainability index development in the context of Malaysian rice cultivation.

3.6.1.1 Assessment Location

The research was conducted in the Integrated Agriculture Development Area of Barat Laut Selangor (IADA BLS). Located in two (2) districts of Selangor, Malaysia: Kuala Selangor and Sabak Bernam. The study area is located between 100.921°E and 101.283°E and 3.404°N and 3.765°N, covering 160,658 ha (Rudiyanto et al., 2023). The irrigation blocks administered by IADA BLS are divided into nine (9), namely: 1. Sawah Sempadan, 2. Sungai Burong, 3. Sekinchan, 4. Sungai Leman, 5. Pasir Panjang, 6. Sungai Nipah, 7. Bagan Terap, 8. Panchang Bedena, and 9. Sungai Panjang. This study area has a humid tropical climate, with monsoons in the northwest and southern seas, resulting in rainfall between October and December and March and May (Suhaila et al., 2010). The average annual rainfall ranges between 2173 mm and 2216 mm (Baig et al., 2023). Dry period between June and August (Rudiyanto et al., 2023).

Selection of IADA BLS as the research location based on its representativeness as one of Malaysia's important irrigated rice granary systems contributing to the rice self-sufficient level, rice production, sustainability and relevance for evaluating sustainability practices in intensive rice cultivation environments (Kamaruddin & Abd. Rashid, 2025; Rahim et al., 2019). This area was officially gazetted by the Selangor

Agriculture Department in 2009 as a high-yield granary (Haris, 2013; Rudiyanto et al., 2023), reflecting the importance of IADA BLS as an agricultural development institution and a strategic player in maintaining domestic rice supply. Since rice was a staple crop in Malaysia and rice productivity and sustainability were always prioritised, IADA BLS were important as representatives of the agricultural system for assessing sustainability performance among rice farmers.

The study location was considered to represent an intensive rice cultivation system in the rice-breadbasket region of Malaysia due to large-scale irrigation infrastructure, coordinated agricultural management systems, and concentration of full-time rice cultivation activities under institutional supervision (Kamaruddin & Abd. Rashid, 2025). Furthermore, this location has multiple irrigation block areas managed by IADA BLS, including irrigation scheduling, agricultural officer extension support, farm supervision, input management, crop monitoring, and productivity coordination (Rusli et al., 2023). These characteristics are similar to cultivation practices commonly found in major granary areas in Malaysia, such as MADA and KADA, because rice cultivation is guided by the Rice Check Guideline Malaysia (Department of Agriculture Malaysia, 2022). Therefore, the agricultural practices for rice crops in this area were in line with the concept of sustainability in this research, where sustainability-related agricultural practices influence the impact across the environmental, economic, and social dimensions. Thus, sustainability assessment requires agriculture setting represents the environmental practices, socio-economic conditions, and production activities to be systematically evaluated.

In addition, the systematic structure of IADA BLS further strengthens the suitability of the research location for sustainability assessment and index development. The presence of organised farmer supervision, strong extension programs, coordinated farm management, and a systematic irrigation system facilitates consistent operations and supports the assessment of sustainability-measurable variables among rice farmers. Thus, these locations enhance the development of context-specific sustainability indices because they reflect the current status of agricultural practices, governance, and management in this Malaysian rice granary system. In essence, the study location was considered suitable and relevant for the development of the Malaysia Sustainable Rice Index (MySRI) to support the Malaysian agenda of increasing rice self-sufficiency and sustainability.

3.6.1.2 Assessment Sampling

The target population for the assessment was rice farmers within the Integrated Agriculture Development Authority (IADA BLS) in Northwest Selangor. A Purposive sampling technique (Campbell et al., 2020; Etikan et al., 2016) was adapted to identify rice farmers who possessed relevant farming characteristics, operational involvement, and experience in sustainable rice cultivation. According to Apostolopoulos & Liargovas (2016), this technique is suitable because it requires human judgment on issues where their specific knowledge is needed. This technique is also effective when the information is available only within a specific community (Tongco, 2007). In addition, this technique allows researchers to obtain data from samples they are confident will provide the best experience, given knowledge of the sample's characteristics (Nyimbili & Nyimbili, 2024). Purposive sampling is used because this research focuses on sustainability assessment and index development at the farm level, which requires information-rich farmers directly involved in rice cultivation and sustainability practices.

In contrast to the random sampling approaches by Krejcie and Morgan (1970) aimed at generalising to the statistical population, this research focused on obtaining operationally relevant sustainability assessment data from rice farmers who actively engaged with the IADA BLS granary. Therefore, this sampling strategy prioritised rice farmers who were directly involved in farm management, decision-making, resource management, and sustainability agriculture practices relevant to the research objective. Because the objective of phase 3 focused on assessment and index construction at the initial assessment stage rather than producing nationwide statistical inference. Therefore, these techniques were considered appropriate for selecting rice farmers capable of providing sustainability assessment information in the Malaysian rice cultivation context.

The selection of rice farmers has been guided by predefined inclusion and exclusion criteria to strengthen index reliability and ensure the suitability of the selected rice farmers for sustainability assessment. The inclusion criteria required a) shall be full-time rice farmers, b) shall manage cultivated land over 4.2 hectares, c) shall be under the supervision of IADA BLS, d) shall be block leaders, and e) shall be stated as rice farmer entrepreneurs. Predefined inclusion criteria have been designed to identify rice farmers who are actively involved in rice cultivation to ensure that the sustainability assessment data collected is relevant. These rice farmers have been chosen because they are directly engaged in farm management, decision-making, resource utilisation, input and productivity management, capacity development and sustainability practices together with IADA BLS. Additionally, farmers appointed as leader or agricultural entrepreneurs possess broader practical experience, institutional exposure, and contextual understanding of management and sustainable practices (Arimbawa et al., 2025; Sujarwo et al., 2023). As for the predefined exclusion criteria, part-time farmers or smallholder farmers may have limited operational involvement in rice farming due to a focus on other full-time occupational commitments and a lower dependence on rice cultivation as a primary economic activity. Thus, their exposure to sustainable farming practices, farm-level decision-making, capacity development and cultivation monitoring differs from that of full-time farmers. Therefore, sampling criteria have been established to ensure the relevance and depth of the sustainability assessment, aligned with the objectives of the sustainability assessment and the farm-level assessment.

There were 9,738 rice farmers registered in IADA BLS, as recorded by the Department of Agriculture Malaysia (2025). Out of 9738 rice farmers, 45 farmers were selected for the assessment study. The selection of rice farmers was done with the help of IADA BLS based on predefined criteria. To ensure broader representation across IADA BLS granaries, rice farmers were selected from 9 irrigation blocks, with 5 farmers per block. This distribution enabled the capture of sustainability performance across nine blocks, operationalizing the measurable criteria and developing an index.

3.6.1.3 Assessment Instrument

A questionnaire instrument was developed to operationalise sustainability criteria, indicators, and sub-indicators, which were validated as measurable assessment variables at the farm level for qualitative assessment and the development of a sustainability index. This instrument serves as the primary data-collection tool for assessing rice farmers' sustainability practices across the environmental, economic, and social dimensions in IADA BLS. The source of the questionnaires was the criteria and indicators validated in phase 2, stage 1, while the questionnaire items and measurable variables were developed together with sub-indicators finalised in phase 2, stage 2. Thus, items in the questionnaire shall be aligned with the research objective (Zamanzadeh et al., 2015).

The use of questionnaires is appropriate because sustainability assessment at farm level requires systematic, standardised, comparable data collection based on sustainability dimensions and practices (Gombkötő et al., 2025; Sais & Benziouche, 2025). Additionally, sustainability assessment encompasses various measurable agricultural variables, such as practices, behavioral items, and operational information, that require a structured assessment procedure. The adapted questionnaire because it allows inexpensive, less effort-intensive self-reports than collecting observational data (Floress et al., 2018). According to Moore & Rutherfurd (2020), questionnaires were often used as instruments in agricultural studies. In addition, many index development studies use questionnaires to assess rice farmers, including Roy et al. (2014), Dantsis et al. (2010), Ekawati et al. (2025), Mungkung et al. (2022), and Bonny et al. (2010). In addition, this method was preferred for its low cost, ease of use, and flexibility (Kormos & Gifford, 2014). Therefore, the use of a questionnaire enabled systematic data collection to capture the environmental, economic, and social dimensions of rice cultivation.

Questionnaires were developed for rice farmers using closed-ended questions, as stated in subsection **3.5.2.2**. The questionnaires were quantified using a five-point Likert scale (Sekaran & Bougie, 2016; Taherdoost, 2022) and a ratio scale (Price et al., 1983; Steven, 1946). The researcher used the Likert scale technique because the sub-indicator was derived from the defined criteria, and the main indicator was used to measure a concept that was challenging to quantify. The Likert scale is suitable for quantifying concepts related to social dimensions, criteria, and their main indicators. Moreover, widely used scale methods across various fields for measuring instruments are important for developing effective questionnaires (Taherdoost, 2019). Further, the method was specifically devised to measure "attitude" in a scientifically accepted and validated manner while addressing the challenges in quantifying the subjective component (Rokeman, 2024). On ratio scales used to present the actual amount to count, especially when asking questions about the amount of input the farmer used per season. Several questions in these studies were adapted to this technique. In addition, this method has been used because it possesses characteristics such as classification, order, fixed distance, and zero origin, which allow quantification of weight, height, distance, population count, and other variables (Dalati, 2018).

Operationalise the calculation of collected data for the procedure sustainability index, likert-scale responses changed into numerical values that are compatible with ratio-scale data before the index calculation procedure, as shown in **sub-section 3.6.1.5**. Transformation process needed to enable normalisation, weighting, and aggregation calculations within the unified quantitative assessment framework. In addition, the instrument's validity was assessed using a Content Validity Index (CVI) with selected experts, as presented in **sub-section 3.5.2.3**. This method ensures that the sub-indicators, along with the questionnaire, are suitable for asking rice farmers. The validators were also selected for their expertise in rice cultivation and in managing rice farmers. Ensuring that the question is clear, readable, consistent, free of redundancy, and relevant to the construct under study is important for questionnaire validity testing (Taherdoost, 2016).

The finalised questionnaire instrument includes four sections. The first section focused on obtaining demographic and farm background information, while the second, third, and fourth sections focused on environmental, economic, and social sustainability assessment components. Detailed description of the questionnaire presented in **APPENDIX 11A**.

3.6.1.4 Data Collection

Data collection was initiated after obtaining formal approval from IADA BLS. A formal application letter requesting permission to conduct the research and assistance in identifying eligible respondents based on the established sample criteria was sent to IADA BLS, as presented in **0A**. After obtaining approval, IADA BLS appointed an agricultural officer to facilitate communication with rice farmers, identify respondents, and assist the researcher during the assessment process. Therefore, IADA BLS involvement was important to ensure that selected rice farmers meet the set inclusion criteria and are actively involved in rice cultivation in the granary area.

The data collection process with rice farmers was conducted in stages across 9 irrigation blocks under IADA BLS supervision, from Sawah Sempadan to Panchang Bedena. Since the data collection took place during the rice cultivation season, the session schedule depended on the availability and operational activities of the rice farmers. Therefore, data collection was carried out flexibly, according to rice farmers' availability, to minimise disruption to their agricultural activities. During data collection, there were also instances when rice farmers could not participate due to withdrawal; replacement respondents, based on predefined sampling criteria, were identified with the help of IADA BLS, who was delegated to achieve the research's defined sample size.

In addition, data collection was conducted based on the suitability of the farmers, including village food stalls, rice farmers' houses, and IADA BLS area block offices in Sungai Besar and Sekinchan. Data collection was conducted under the researcher's guidance, both manually and online, with rice farmers. For manual questionnaires, the researcher conducted face-to-face interviews with rice farmers who chose this method, using the provided survey form. However, the online questionnaire was administered via Google Meet at the farmer's convenience, and the researcher recorded the farmer's responses. However, only one farmer chose to use Google Meet. The advantage of adopting this online method is that it facilitates data transfer for analysis (Lim & Ahad, 2014). In addition, it facilitates rice farmers who do not have time during the day to give their answers.

Facilitated the management of raw data for sustainability index analysis, and the collected raw questionnaire data was transferred into a Microsoft Excel Macro Dashboard developed by the researcher. This dashboard facilitates data organisation, coding, transformation, and conversion of questionnaire responses into a computer-readable format for the sustainability index calculation procedure. The Microsoft Excel Macro Dashboard is presented in Figure 3.20 for several questions, and the complete questionnaire is presented in **APPENDIX 13A**.

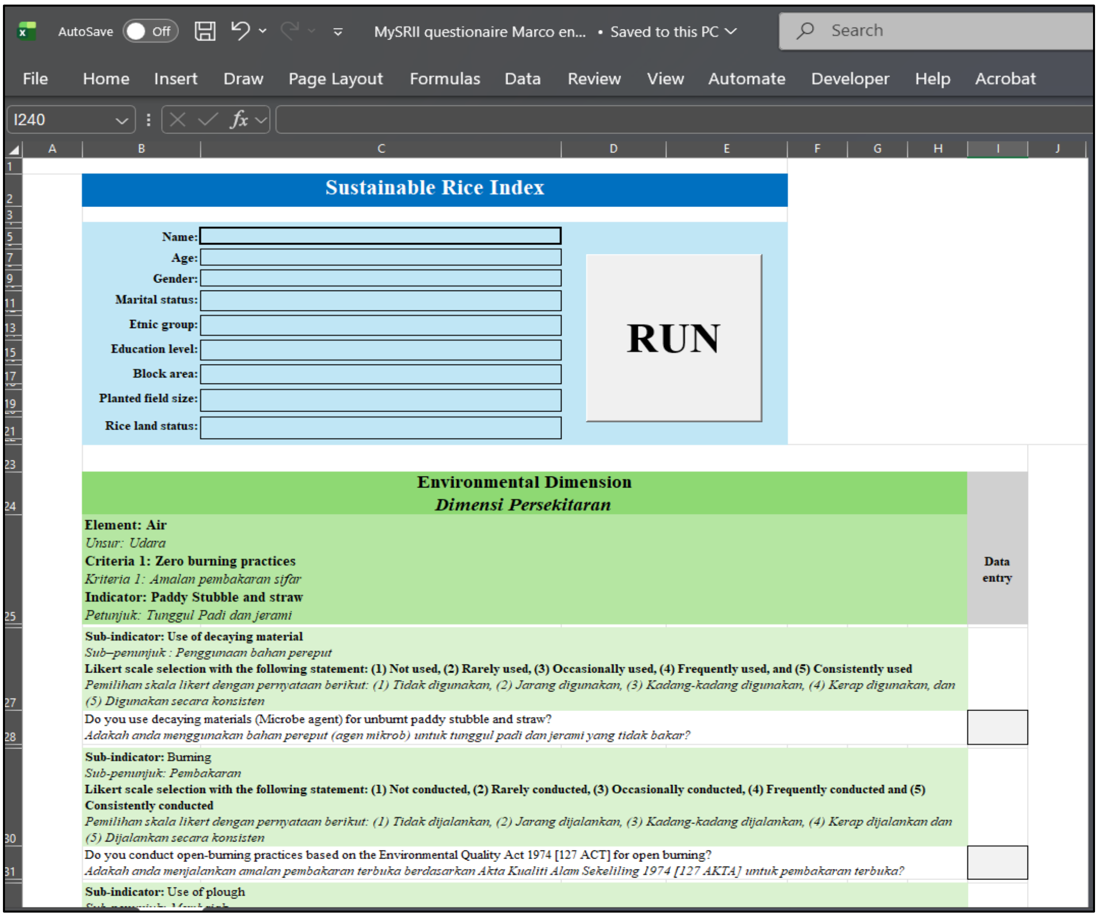


Figure 3.20 Microsoft Excel Macro Dashboard (Created by Researcher)

3.6.1.5 Analysis of Assessment Data

The collected sustainability assessment data were analysed using descriptive methods, an approach for summarising, organising, and interpreting multidimensional sustainability variables. This method analyses and summarises data to obtain an overview of characteristics and distributions such as mean, median, and mode (Alabi & Bukola, 2023). This method is used to assess frequency distributions and calculate key statistics for individual indicators (Mazziotta & Pareto, 2025). Furthermore, this method allows researchers to describe and summarise large quantitative data sets in a meaningful way (Baffeo & Smith, 2019). Therefore, the use of descriptive methods in this research enables the systematic improvement of the interpretation and management of sustainability assessment data prior to index calculation.

Since sustainability assessment involves environmental, economic, and social dimensions measured using different scales and data structures, early data preparation and transformation were conducted to ensure comparability across variables. The data collected through manual and online questionnaires is managed and entered into Microsoft Excel. The use of Microsoft Excel facilitates data management, transformation, and preparation for the subsequent sustainability index procedure. The data transformation procedure for the Likert-scale assessment variable has been standardised from Likert-scale responses (1, 2, 3, 4, 5) to numerical values of 10, 30, 50, 70, and 90 to facilitate comparability across sustainability variables. The ratio-scale variable involved directed measurable agricultural quantities was retained in its original numerical value without transformation. Thus, this procedure ensured that the measurable variables remained quantitatively represented and that the actual agricultural practices among rice farmers and the index were primarily presented as quantitative tools in numerical form (Booysen, 2002).

After performing data management and transformation, the analysis continued with a cleaning and screening process to identify inconsistencies and data entry errors before the data were entered into the index development process. Following the cleaned and screened process, the finalised assessment dataset was transferred to a separate Microsoft Excel file for constructing the sustainability index calculation and implementing the mathematical algorithm.

3.6.2 Sustainability Index Development

The Malaysia Sustainable Rice Index (MySRI) has been developed to provide systematic, quantifiable sustainability assessment practices for rice farmers in Malaysia. The index development needs to capture the multidimensionality of the sustainability concept, such as environmental, economic, and social dimensions, which requires integration into a structured and interpretable assessment. A sustainability index is a widely used tool that simplifies complex sustainability variables into measurable, comparable performance indicators to support sustainability assessment, monitoring, interpretation, and decision-making (Singh et al., 2012).

The development of MySRI aligns with the third objective, which focuses on sustainability assessment and on developing an index based on quantitative assessment and mathematical aggregation approaches. The development of this index is based on the validated sustainability criteria, indicators, and sub-indicators established in Phases 1 and 2, as well as the assessment of rice farmers in Phase 3. Because sustainability assessment involves multiple variables measured using different units, scales, and dimensions, an index development procedure is required to standardise, compare, weight, aggregate, and interpret the sustainability assessment data into a single numerical value.

To ensure transparency and future index improvement, MySRI developers have followed several index development procedures consisting of: (1) Sustainability criteria, indicator, and sub-indicator selection; (2) data collection; (3) data normalisation; (4) weighting; (5) aggregation; and result interpretation. This procedure has been adapted from an established sustainability index development approach (Research Centre, 2008; Ziemba et al., 2022) and ensures the transformation of multidimensional farm-level sustainability into interpretable sustainability performance outcomes. Figure 3.21 shows the overall flow of the adapted index development procedure.

MySRI has been operationalised through a structured quantitative assessment in Microsoft Excel to facilitate the computation of mathematical algorithms and the calculation of the sustainability score. Microsoft is inexpensive and readily available to researchers, students, and small companies, and it supports data manipulation and leverages this spreadsheet program (Perzina & Ramik, 2014). In addition, this tool serves as a powerful development platform, providing procedural and declarative programming languages useful for complex numerical computation (Bovey, 2009). Therefore, Microsoft Excel is one of the spreadsheet tools suitable for developing MySRI.

The development of the MySRI structure has been designed to ensure that sustainability assessment remains transparent, operationally measurable, and contextually relevant to Malaysian rice cultivation practices. Through the integration of validated sustainability criteria, indicators, sub-indicators, standardised assessment procedures, and mathematical algorithms, MySRI provides a structured model for assessing sustainability performance among rice farmers in the Malaysian granary area.

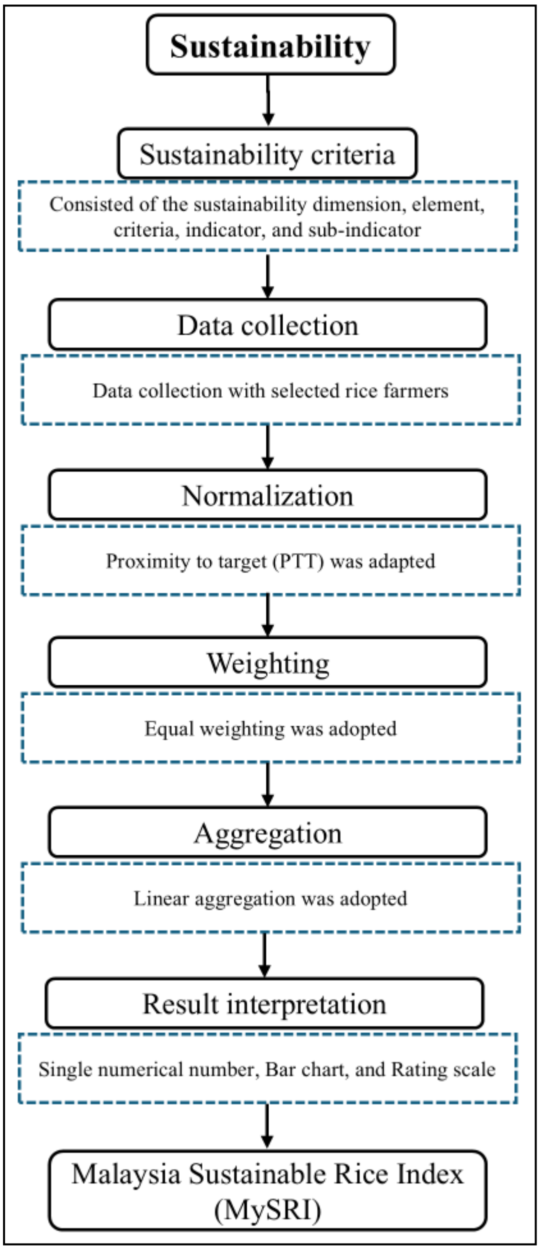


Figure 3.21 Index Development Flowchart (Created by Researcher)

3.6.2.1 Sustainability Criteria or Framework

The selection of sustainability criteria, indicators, and sub-indicators was completed in objectives 1 and 2 of this study. The Malaysian Sustainable Rice Index (MySRI) consists of four layers of assessment: dimensions, elements, criteria, indicators, and sub-indicators, as shown in Figure 3.22. The rice farmer was evaluated based on three (3) dimensions of sustainability: environmental, social, and economic. Then, each element consists of its assigned criteria. The criteria describe a general appraised term. The criteria included several indicators that called for measuring sustainability practices. Then, for a sub-indicator, a measurable unit is selected based on relevance, transparency, data quality, and the data custodian (Ahamad et al., 2015).

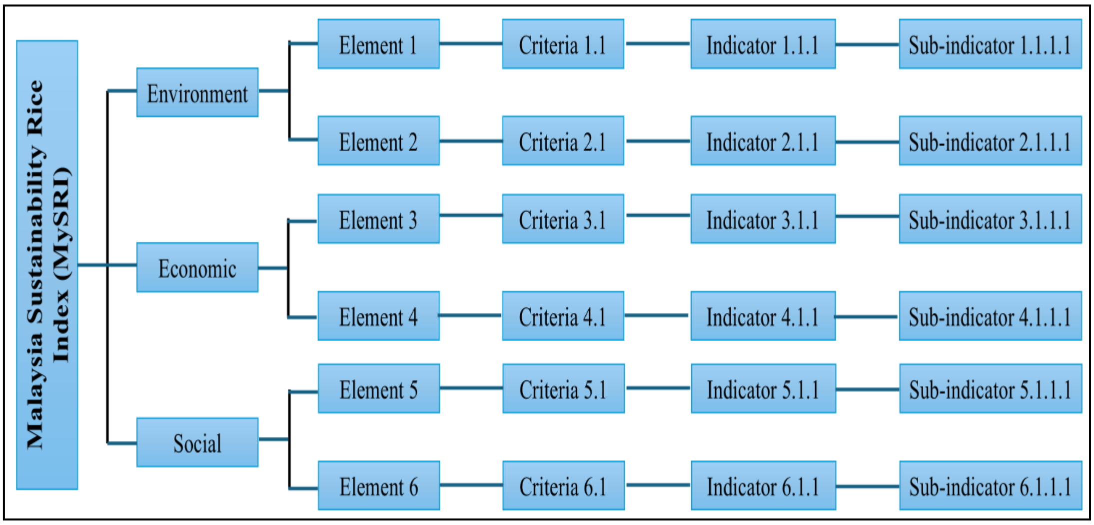


Figure 3.22 Layer of Assessment (Created by researcher)

3.6.2.2 Data Collection

Data collection was conducted with rice farmers selected under the supervision of the Integrated Agriculture Development Authority of North Selangor (IADA BLS) in the districts of Kuala Selangor and Sabak Bernam. Source of data from the rice farmers and aligned with the IADA BLS official for the validity of the data. A detailed approach to the collected data is presented in subsection 3.6.1. In addition, the researcher had also established the indicator standard or target value. The researcher established a standard value to facilitate performance comparisons across different geographical areas, enrich information, ensure easy interpretation of indices, and provide richer insights for users (Garcia et al., 2022). The hierarchy of standard value, adapted from Jamaludin et al (2018): 1) regulation, 2) industry target, and 3) best performance, is described below.

1) Regulation

   The SAFA framework rating scale value of 40-60 was used as the standard for the sub-indicators, which were measured on a Likert scale.

2) Industry target

   IADA BLS and the Department of Agriculture Malaysia target values were also used for the ratio scale, particularly for the yield indicator.

3) Best performance

For indicators without target values, the researcher used the mean as the assessment data. The desired indicator level can be determined by the reference average value (De Olde et al., 2016; Van Couwenbergh et al., 2007).

3.6.2.3 Data Normalisation

Some of the sub-indicators used in this index construction have been measured using different units, scales, and data structures, requiring normalisation before being integrated into the index aggregation. In index development, these approaches were necessary because they standardize indicators on a common, comparable scale, allowing the integration of multidimensional variables into sub-indices and the overall index while preserving compatibility among dimensions (Krajnc & Glavič, 2005). Therefore, the normalisation process in this phase aims to standardise the sustainability variable finalised in phase 2 while preserving the relative sustainability performance represented by each variable.

The sub-indicator was classified into two performance categories based on the direction of sustainability interpretation. The sub-indicator with a high value, indicating good performance, was designated type A, whereas the sub-indicator with a high value indicating poor performance was designated type B (Jamaluddin, 2018; Tan et al., 2015). Therefore, researchers have adopted the Proximity to Target (PTT) normalisation technique (Jamaludin et al., 2018). Next, the researcher applied the Categorical Scales Normalisation technique to derive the final data from the Likert-scale questionnaire (Joint Research Centre, 2008). Proximity to Target (PTT) is explained in Figure 3.23. X, Y, and Z are indicator data for the target. The choice of normalisation methods is very important, as it can influence the steps in the index development process (Joint Research Centre, 2008).

The Proximity to Target (PTT) or Mix Max approaches were adopted because they directly meet the need to convert all indicator values into bounded, comparable intervals (1,0) and to allow interpretation of best and worst performance in the data set (Joint Research Centre, 2008). This approach is also widely used and has been adopted by many index makers, such as the Human Development Index (HDI) (Mazziotta & Pareto, 2022; Talkuder et al., 2017). Meanwhile, the Categorical Scale method was adopted because it allowed indicators derived from qualitative domains or survey-based information to be translated into numerical or percentile values, even in the absence of quantitative data (Joint Research Centre, 2008; Zanarotti & Pagani, 2015). Integrating PTT and Categorical Scale normalization approaches enabled the development of the Malaysia Sustainable Rice Index (MySRI) to standardise quantitative and qualitative variables derived from the finalised criteria and indicators.

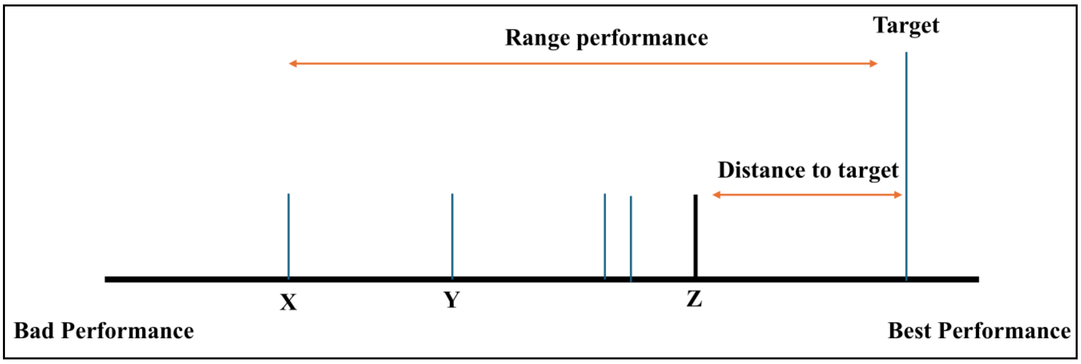


Figure 3.23 Proximity to Target (Ahamad et al., 2015)

Based on Figure 3.23, shown at shorter distances, the indicator performance is close to the target value, indicating good performance, while a greater distance from the target indicates lower performance. All variables have been normalised from zero (0) to one hundred (100). A move towards zero (0) indicates low performance, and one hundred (100) indicates high performance. Type A and B formulas are shown in Table 3.13.

Table 3.13
Type A and B Formula

No	PTT type	Formula
1	Type A	$PTT_{ij} = \dfrac{\left[\left(t_i - \min_{(m_{ij})}\right) - \left(t_i - m_{ij}\right)\right] x100}{\left(t_i - \min_{(\mathrm{m_{ij}})}\right)}$
2	Type B	$PTT_{ij} = \dfrac{\left[\left(\max_{(\mathrm{m_{ij}})} - \mathrm{t_i}\right) - \left(m_{ij} - t_i\right)\right] x100}{\left(\max_{(\mathrm{m_{ij}})} - \mathrm{t_i}\right)}$

PTT_{ij} is the normal value for rice farmer j and the indicator for j. For m_{ij} is the final data value of the rice farmer and the indicator. The values of $max_{(m_{ij})}$and $min_{(m_{ij})}$ are obtained from the highest and lowest values in the data set m_{ij} which is used as a performance benchmark. In the normalisation technique for categorical scales, each indicator is assigned a score. This category can be numerical, such as one to three stars, or qualitative, such as “fully achieved,” “partially achieved," or “not achieved” (Joint Research Centre, 2008). In creating MySRI, scores are assigned based on the percentiles specified in the formula in Table 3.14.

Table 3.14
Categorical Scale Formula

No	Normalization technique	Formula
1	Categorical	$I_{qc}^{t} = \begin{cases} 0 & \text{if } x_{qc}^{t} < P^{15} \\ 20 & \text{if } P^{15} \le x_{qc}^{t} < P^{25} \\ 40 & \text{if } P^{25} \le x_{qc}^{t} < P^{65} \\ 60 & \text{if } P^{65} \le x_{qc}^{t} < P^{85} \\ 80 & \text{if } P^{85} \le x_{qc}^{t} < P^{95} \\ 100 & \text{if } P^{95} \le x_{qc}^{t} \end{cases}$

This method rewards high-performing farmers and punishes low-performing ones. This scale technique follows SAFA's rating method. The SAFA scale provides a 5-point performance rating, as presented in Table 3.15 (SAFA, 2014).

Table 3.15
Rating Scale based on SAFA

Performance	% score
Dark green (Best)	80-100
Light green (Good)	60-80
Yellow (Moderate)	40-60
Orange (Limited)	20-40
Red (Unacceptable)	0-20

3.6.2.4 Weighting

An equal-weighting approach has been adopted in constructing the index to assign balanced contributions across variables within the Malaysian Sustainable Rice Index (MySRI). Equal weighting is used for indicators that have the same level of importance or for which there is no statistical evidence to support other weights (Nardo et al., 2005). This method is simple and can be adapted by other researchers (Land, 2006). Equal weighting is simple, replicable, and straightforward, and new researchers can easily use it to develop a sustainability index (Gan et al., 2017). Additionally, this method facilitates explanation and simplifies the communication of results when using simple additive weighting (Libório et al., 2025). This method has been used because the

MySRI framework considers environmental, economic, and social aspects as equally important and interconnected in achieving sustainable rice farming.

In addition, equal weighting was chosen to reduce biases resulting from prioritising certain sustainability dimensions in the absence of empirical evidence. There are other methods for obtaining empirical evidence (Gan et al., 2017), but the index construction in this research does not focus on this method, as it focuses on testing the developed index. This method has been applied in index construction (Singh et al., 2012) for transparency, ease of interpretability and early-stage development. Several established indices that use this method are the Living Planet Index, Human Development Index, Genuine Saving Index, and International Index (Liborio et al., 2022; Loh et al., 2005; UNDP, 1990; World Bank, 1999). In the context of index construction in this research, an equal-weighting approach is needed to integrate additive aggregation procedures, ensuring that assessment data can be synthesized into a single index score and enabling comparability of dimension performance scores among rice farmers. Table 3.16 shows the equal-weighting formula used to develop MySRI. Therefore, 20 criteria, along with their indicators and sub-indicators, are assigned equal weight in the index.

Table 3.16
Equal Weighting Technique

No	Method name	Type	Formula
1	Equal weighting	Equal	$\omega_i = \omega, \quad i = 1, \dots, m$ $\omega_i$is the weight of the i^{th} indicator, and ω is a constant used as the weight for all the indicators

In compiling the index, all dimensions, criteria, and indicators were treated equally. As shown in Table 3.17, the environmental, economic, and social dimensions comprise 10, 5, and 5 criteria, respectively. The total of 100% is divided equally among three dimensions, resulting in 3.33% for each environmental criterion and 6.66% for economic and social. Therefore, the environmental dimension receives an overall weight of 33.33%, the economic dimension 33.33%, and the social dimension 33.33.%. .%. Then, the dimension weightage percentage was divided based on the number of criteria, and then the criteria were divided based on the number of indicators.

Table 3.17
The Weightage for Each Dimension, Criteria and Indicators.

	Dimension	Criteria	Indicator	Weightage			Total
1	Environment					33.3%	100.0%
2		Zero burning practices			3.33%		
3			Paddy Stubble and straw	3.33%			
4		Water resources			3.33%		
5			Water management	3.33%			
6		Pre-planting			3.33%		
7			Land Suitability	1.67%			
8			Surveillance of Paddy Field	1.67%			
9		Timing of harvest			3.33%		
10			Timing of harvest	1.11%			
11			Harvesting equipment	1.11%			
12			Post-harvest handling	1.11%			
13		Efficiency of energy use			3.33%		
14			Non-renewable energy consumption	3.33%			
15		Waste management and disposal			3.33%		
16			Mechanism of action for reducing non-renewable energy consumption	1.11%			
17			Waste management standard operating procedure	1.11%			
18			Farm operational disposal	1.11%			
19		Planting material			3.33%		
20			Pure quality seed	3.33%			
21		Pest Input			3.33%		
22			Chemical pesticide	1.67%			
23			Organic pesticide	1.67%			
24		Fertilizer Input			3.33%		
25			Chemical fertilizer	1.67%			
26			Biological fertilizer	1.67%			
27		Species Diversity			3.33%		
28			Integrated Pest Management (IPM)	3.33%			
29	Economy					33.3%	
30		Traceability			6.66%		
31			Record keeping	6.66%			

32		Stability of Production			6.66%	
33			Guarantee of production levels	6.66%		
34		Stability of Supply			6.66%	
35			Procurement Channels/ Input Supplies	6.66%		
36		Liquidity			6.66%	
37			Net Cash Flow	3.33%		
38			Safety Nets	3.33%		
39		Value Creation			6.66%	
40			Fiscal Commitment	6.66%		
41	Social					33.3%
42		Quality of Life			6.66%	
43			Right to Quality of Life	6.66%		
44		Capacity Development			6.66%	
45			Capacity Development	6.66%		
46		Right to use land			6.66%	
47			Right to use land	6.66%		
48		Employment condition			6.66%	
49			Employment relations	6.66%		
50		Workplace safety			6.66%	
51			Safety Instruction and First Aid	0.95%		
52			Tools and equipment	0.95%		
53			Training of pesticide applicators	0.95%		
54			Personal protective equipment (PPE)	0.95%		
55			Washing and changing	0.95%		
56			Applicator restrictions	0.95%		
57			Re-entry time	0.95%		

3.6.2.5 Aggregation

The aggregation process has been used to combine the weighting and normalisation of sustainability indicators into the sustainability performance scores of rice farmers, based on environmental, economic, social, and overall scores. The aggregation approach is important in index development because it combines multiple indicators into a single interpretable index for assessment and comparison purposes

(Joint Research Centre, 2008). Since the sustainability assessment of rice farmers involved multiple indicators measured across 3 dimensions, an aggregation approach is necessary to convert the calculated variables into a unified sustainability index performance score.

An additive aggregation approach was adopted to calculate the sustainability score (Joint Research Centre, 2008; Ziemba et al., 2022). The additive aggregation method was adopted for its simplicity and as a common approach to index development that combines weighted indicators. The method also involved calculating the position of each rice farmer for each indicator separately and summing the positions, as in the Information and Communication Technologies Index (Fagerberg, 2001). This method is based on ordinal information (Borda Rule). Furthermore, this method facilitates the integration of normalisation and weighting techniques of indicators into an interpretable sustainability score, condensing the complex or multidimensional concept to a single measure, with the assumption that lower performance indicators can be balanced by higher performance in other indicators (Dobbie & Dail, 2013; Joint Research Centre, 2008). The consideration of compensatory assumptions was acceptable because MySRI development was intended to provide the overall sustainability performance of rice farmers rather than to evaluate individual sustainability indicators. Therefore, this method allows sustainability performance to be represented as a balanced, integrated score across environmental, economic, and social dimensions.

This method is very popularly used in several development indices, such as the Human Development Index (HDI) and the Commitment to Development Index (CDI), because of its simplicity (Chowdhury & Squire, 2006; Zhou et al., 2010). For index development, linear aggregation of the weighted and normalised individual indicators was used, following Jamaludin et al. (2018). The aggregation procedure was conducted using the framework, from the sub-indicator to the overall sustainability index score. These procedures ensure the systematic integration, preservation of traceability, and interpretation of the sustainability score, as shown in Figure 3.24. Aggregation calculations started with the criteria score formula, the mathematical criteria aggregation score, the dimension score, and the index score, as shown in Table 3.18.

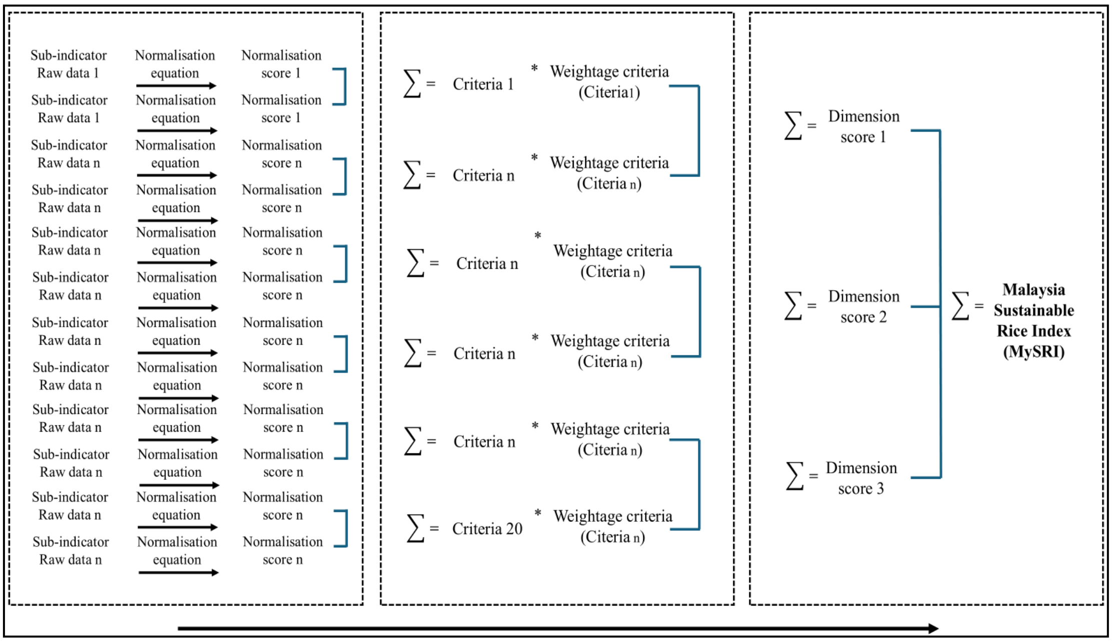


Figure 3.24 Summary of Index Calculation (Created by Researcher)

Table 3.18
Index Calculation with Formula

No	Calculation name	Formula
1	Criteria score	$C_{jk} = \sum \frac{PTT_{ij}}{No\ of indicator_k}$ In the criteria formula, to obtain the criteria C_{jk} by summing PTT_{ij} for the k referring to the j rice farmer and the i indicator, then dividing it by the number of indicators for the k parameter.
2	Criteria aggregation score	$CAS_{jk} = C_{jk} \times weightage_k$ The obtained C_{jk} value is then multiplied by the weight for the k criterion, namely $weightage_k$ to produce the aggregation score of the Criteria C_{jk} for the *j rice farmer and the k* criteria.
3	Dimension score	$D_{jI} = \sum CAS_{jk}$ Value CAS_{jk} is aggregated to get the dimension score, D_{jI} for the *j* rice farmer, *I* for dimension.
4	Index score	$Ij = \sum D_{jI}$ D_{jI} for *j* rice farmer, the *I* dimension aggregated obtained the index score Ij for the *j* rice farmer.

3.6.2.6 Result Interpretation

The final step in developing the Malaysia Sustainable Rice Index (MySRI) involved interpreting the sustainability scores derived from the index. This process was essential to explain the sustainability performance of rice farmers in an easily understandable manner. Therefore, the sustainability scores were grouped into defined performance categories and score ranges to show the different levels of sustainability performance achieved by rice farmers. This process also allowed sustainability performance to be assessed using the overall index score, dimensions, criteria, and indicators. Therefore, it enabled the identification of strengths and weaknesses in sustainability performance that may require improvement. To ensure transparency and consistency, the sustainability performance categories and score ranges were determined based on the SAFA framework rating scale, numerical values, tables, and bar charts to facilitate understanding and comparability of scores among rice farmers.

3.7 Research Ethics

Every study must be conducted ethically. Before conducting this study, the researcher applied for research ethics approval because it involved humans. The purpose of research ethics approval was to protect the rights, safety, and well-being of respondents and to ensure compliance with laws and regulations. The researcher submitted a research ethics application in the RED System through the Department of Research and Innovation (UiTM Research Ethics Committee), which required approval from the faculty level to the UiTM REC level. Two applications were submitted and were successful in securing interviews with experts in agriculture and sustainability **(APPENDIX 5A)** and with rice farmers for questionnaire sessions (**APPENDIX 14A**).

3.8 Chapter Summary

This chapter has systematically described the study design, data collection and analysis procedures, and index development used to achieve the main research objectives of developing the Malaysia Sustainable Rice Index (MySRI). Overall, the research methodology has been designed using a mixed-methods approach combining qualitative and quantitative components to ensure the conceptualisation, validation, and usability of the sustainability assessment of rice-farmer cultivation practices at the farm level. This method was chosen because developing a sustainability index requires an in-depth exploration of theoretical and conceptual frameworks, followed by quantitative measurements that enable the objective calculation of index scores.

The methodological structure comprises three main phases aligned with the study objectives. The first phase focuses on exploring sustainability criteria and indicators through a literature review. The second phase focuses on refining criteria and indicators through interviews with expert panels. The last phase focuses on assessing sustainable agricultural practices and developing the MySRI index. Overall, this chapter presented MySRI as an integrated methodology framework that begins with theoretical explanation, refinement, and empirical application in the field. This phased design ensures that the index developed is context-specific, validated, and of practical relevance for assessing rice-farmer practices in Malaysia. The next chapter presents the study's results and findings for each research objective.

CHAPTER 4
RESULTS AND FINDINGS

4.1 Introduction

This chapter presents the findings from the development of the Malaysian Sustainability Rice Index (MySRI). First, the objective (1) was to present the findings of the identification of the sustainability criteria and indicators used in the index development. A description of the agricultural sustainability framework, both international and local, presents the results of the expert review of the proposed sustainability criteria. Second, the objective (2) presents the findings from interviews with experts regarding the proposed sustainability criteria. The chapter also presents the results of the sustainability criteria and their leading indicators as theoretical sustainability criteria or framework in the development of the index. Next, the chapter presents findings from the review of sustainability sub-indicators and the final sustainability criteria, as well as the leading indicators and sub-indicators used in the assessment index. On the other hand, the third objective presents the findings from the assessment of rice farmers and the results of the index development. Presents the demographics of rice farmers who are the respondents of the assessment and the results of the index analysis from the assessment of sustainable agricultural practices of rice farmers.

4.2 Objective 1: Proposed Sustainability Criteria and Indicators

Objective 1 focuses on reviewing the sustainability criteria and indicators finalised by agricultural and sustainability experts. Expert views were sought to assess the suitability of the criteria and indicators used in the developed index to evaluate rice farmers' sustainability practices.

4.2.1 Sustainability Framework

The sustainability framework in Malaysia selected for review is Guidance Document MS2530-2-1:2022 Malaysian Sustainable Palm Oil (MSPO) – Part 2 – 1: General Principles for Independent Smallholders (Less than 40.46 Hectares) and

Malaysia Good Agriculture Practices (MyGAP) – Crop Production. The international frameworks are the Sustainability Assessment of Food and Agriculture System (SAFA) Guidelines, the Sustainable Rice Platform (SRP) Standard for Sustainable Rice Cultivation, and the Roundtable on Sustainable Palm Oil (RSPO) – Independent Smallholder Standard.

4.2.2 Summary of Review Sustainability Criteria or Framework

Each sustainability criterion and indicator was carefully reviewed from the selected sustainability framework. The analysis of the review revealed that the criteria are based on environmental, economic, and social dimensions. Two (2) criteria were selected from the governance dimensions based on their applicability. Every criterion and its indicator is selected based on current rice farming practices, as outlined in the Malaysia Rice Check Guidelines, and on the issues farmers face. Table 4.1 summarises 27 criteria and their indicators by dimension.

Table 4.1
Summary of Review of Sustainability Criteria and Indicators

Dimension	Element	Criteria	Indicator
Environmental	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
		Waste management and disposal	Management plan
			Reusing waste
		Planting material	Pure quality seeds
		Pest Input Control	Chemical and biological pest control.
		Fertilizer Input	Inorganic and organic fertilisers
	Biodiversity	Ecosystem diversity	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
		Stability of Supply	Procurement Channels
			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

Moreover, each criterion and its indicator have their own description or definition to provide information for the assessment. The review framework, with modifications to rice cultivation in Malaysia, drives the description. There is also a description, drawn from the Malaysia Rice Check Guideline, to align with rice cultivation practices. The detailed description and indicators based on the proposed sustainability criteria are presented in **0A**.

4.3 Objective 2: Refinement of Proposed Sustainability Criteria, Indicators, and Sub-Indicators

Objective 2 focuses on refining sustainability criteria and indicators by reviewing the sustainability framework with experts in sustainability and agriculture, and on reviewing the sub-indicators used in the assessment index in Objective 3. Thematic analysis has been used to finalise the proposed sustainability criteria (Braun & Clarke, 2006).

4.3.1 Refinement of Proposed Sustainability Criteria and Indicators

These experts have refined 27 sustainability criteria, resulting in 20 finalised criteria as the theoretical foundation for the index assessment. The refinement was conducted by removing and merging criteria that were not measurable, redundant, or less contextually relevant from the 27 proposed sustainability criteria; moreover, the rationale for refining the 20 finalised criteria is presented in the discussion chapter. The criteria are, Zero burning practices, Water resources, Soil quality, Replanting, Harvesting and post-harvesting, Efficiency of energy use and use of renewable energy, Waste management and disposal, Planting material, Pest Input control, Fertilizer Input, Ecosystem diversity, Species Diversity, Profitability, Traceability, Stability of Production, Stability of Supply, Liquidity, Risk Management, Value Creation, Local Procurement, Quality of Life, Capacity Development, Fair Access to Means of Production, Right to land use, employment conditions, living conditions, and workplace safety.

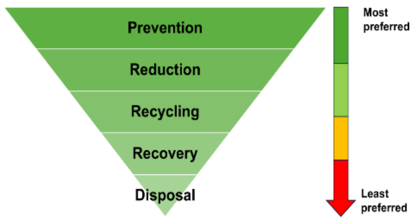
After analysing the interview results, the researcher has improved the proposed criteria and indicators. The criteria and indicators apply to all farm-level processes in rice production, from planting through postharvest, within the farmer's control of 4.2 hectares of rice field. The criteria and indicators were developed to suit this rice farmer, who was supervised by the Integrated Agriculture Development Area (IADA). The finalised sustainability criteria were categorised into three main pillars: environmental, economic, and social. The structure of the criteria and indicators comprises three dimensions, three principles, 12 elements, 20 criteria, and 58 indicators. A full description of the criteria and their indicators is presented in Table 4.2.

Table 4.2
Detailed Description of Sustainability Criteria and Indicators

Dimension	Element	Criteria	Indicator
Environment	Air	Criteria 1: Zero burning practices This criterion aims to ensure that rice farmers are encouraged not to burn rice residue openly at any stage of rice cultivation and operations at the farm level unless permitted by the relevant local authorities. The farmer encourages sustainable rice residue practices.	Indicator 1: Rice Stubble Rice stubble is managed sustainably to minimise greenhouse gas emissions and environmental impacts and to retain soil quality. Rice stubble is: 1) Controlled Burning is allowed (on non-wet rice field conditions) and must follow the Environmental Quality Act 1974 [127 ACT] for open burning. 2) Farmers should use decaying material (micro agent) if the stubble is not burned. 3) Farmers should allow ploughing in the empty rice field to thresh the rice stubble, the field without using decaying material (micro agent), by-product usage, and burning to decompose naturally when there is a continuous wet situation (Raining Day).
			Indicator 2: Rice Straw Rice straw is managed sustainably to mitigate greenhouse gas emissions, minimise environmental impacts, and retain or improve soil quality. Rice straw is: 1) Controlled Burning is allowed for rice straw (on non-wet rice field conditions) and must follow the Environmental Quality Act 1974 [127 ACT] for open burning. 2) Farmers should collect rice straw for by-product usage. 3) Farmers should use decaying material (micro agent) if the straw is not used as a by-product or burned. 4) Farmers should allow ploughing in the empty rice field to thresh the rice straw in the field without using decaying material (micro agent), by-product usage, and burning to decompose naturally when there is a continuous wet situation (Raining Day).
	Water	Criteria 2: Water resources The intent of this criterion is for the farmer	Indicator 1: Water management The intent of this criterion is for the farmer to be aware that, despite being a renewable resource,

	to be aware that, despite being a renewable resource, water, if not correctly managed, could still result in shortages and deterioration in the quality of the supply. Applicable to rice farmers who have an irrigated production system.	water, if not correctly managed, could still result in shortages and deterioration in the quality of the supply. Applicable to rice farmers who have an irrigated production system Measures are in place to enhance water-use efficiency for the irrigated production system (Wet and dry season) implemented by rice farmers: 1) Shall ensure timely crop establishment based on the irrigation agency timetable. 2) Should use a flood-tolerant variety during the wet season. 3) Should use a dry-tolerant variety during the dry season. 4) Should implement alternate wetting and Drying (AWD) during the dry season. 5) Shall no groundwater extraction be conducted without the irrigation agency's consent. 6) Shall inform the irrigation agency of the water irrigation issue immediately. 7) Shall follow drainage timing based on the irrigation agency timetable.
Land	Criteria 3: Pre-planting Pre-planting in rice production refers to the preparation steps undertaken by rice farmers before planting rice seedlings. These steps are crucial for ensuring a healthy and productive rice crop. The preparation steps implemented by rice farmers are based on their own control. Any steps taken by service providers or agricultural agencies are not considered part of farmers' implementation.	Indicator 1: Land suitability Rice farmers shall receive a concern form from agriculture agencies on the status of rice field pH and CEC before proceeding further to the pre-planting step.
		Indicator 2: Surveillance of rice field Rice farmers shall make sure: 1) Irrigation and drainage systems as well as water control structures work well 2) Maintenance of the field bund (Batas) must be strong, clean from vegetation and not leaking. 3) The farm road is sufficient with a width of at least 4.5 m.
		Indicator 3: Land preparation The rice farmer shall make sure: 1) Land preparation follows the suggested schedule according to the agriculture agency or "Rice Check Wheel." 2) Before ploughing the land, make sure the rice fields are cleaned of straw, stubble, weeds, and wind rice. 3) Supervise land preparation activities to be carried out properly with the presence of rice farmers or service providers.
	Criteria 4: Harvesting and post-harvesting	Indicator 1: Timing of harvest

	The criteria of harvesting and post-harvesting in rice cultivation encompass the methods and practices involved in gathering mature rice crops and handling them after harvest. Efficient harvesting and post-harvest practices are essential for maximising yields, preserving grain quality, and ensuring food security. Any steps taken by service providers or agricultural agencies are not considered part of farmers' implementation.	The rice farmer shall make sure: 1) Dry the water in the rice fields 10 - 14 days before harvesting. If Rain occurs on the day of harvest, farmers are encouraged to wait 24 hours to start harvesting operations. 2) Harvest rice when approximately 85-90% of the rice grains in the stalk are yellow.
		Indicator 2: Harvesting equipment Rice is harvested with clean equipment to prevent contamination and mixing of varieties, weeds, and pests. Machines (if used) are adjusted to optimal settings and operated according to crop and field conditions, resulting in minimal quality loss and shattering loss. Harvester operations must be supervised to minimise yield loss and guarantee the quality of results through a focus on the following: 1) Make sure the jib adjustment is done on the rake side, mowers, and blowers to be able to operate with high efficiency. 2) Rice needs to be cut ⅓ from the tip of the tree height. 3) The harvester width should be adjusted to ¾ of the width of the cutting table. 4) The harvester operates at medium speed (<4km/h). 5) The harvester should be handled carefully, especially when turning, to reduce damage to the soil.
		Indicator 3: Post-harvest handling Make sure that the harvested rice is sent immediately to the factory to preserve its quality. The rice farmer shall make sure: 1) Trucks carrying rice should be covered with canvas. The floors and walls of the truck are designed to avoid loss of yield. 2) The harvested rice should be sent to the drying centre/indoor factory for 24 hours. 3) A farmer or an acknowledged representative must be present when the rice is graded at the rice mill or buyer collection centre.
	Criteria 5: Efficiency of energy use This criterion aims to raise awareness of the impacts of using non-renewable energy on climate change and resource optimisation. The farmer should initially collect data on energy consumption for non-renewable	Indicator 1: Non-renewable energy consumption The farmer should monitor non-renewable energy consumption to reduce costs. Fuel usage should be monitored for all activities except usage by the service provider or contractor—fuel such as gasoline/petrol and biodiesel.
		Indicator 2: Mechanism action reducing non-renewable energy consumption

	energy. Whenever possible, an appropriate mechanism of action should be established to reduce non-renewable energy consumption.	Rice farmers should implement mechanisms to reduce non-renewable energy consumption, such as: • Use of the service provider
Material and energy	Criteria 6: Waste management and disposal This criterion aims to prevent pollution from waste disposal and encourage resource optimisation in rice production by rice farmers.	Indicator 1: Management plan The farmer encourages consideration of the waste management hierarchy of controls. Starting one (1) is the most preferred control until the least preferred control, to five (5), as shown below:
		 The farmer encourages the use of a waste management hierarchy of control, standard procedures, and operating (SOP) forms on their farm. The farmer is encouraged to undertake the most preferred waste management control before deciding on the following line of control. The control should be based on current practices and recommendations from the agriculture agency to promote a more sustainable approach to waste management. The farmer should also recycle potential wastes as nutrients and/or convert them into value-added by-products (e.g., Rice straw and stubble).
		Indicator 2: Farm operational disposal This refers to solid and liquid waste generated by rice farmers during rice production, excluding waste generated by service providers/contractors. The waste included below: a) Solid waste I. Agricultural machinery and equipment waste: Lubricant and oil unused containers, worn-out parts, plastic pipes, II. Empty chemical and bio-organic pesticide and fertiliser containers or packaging

		III. Empty rice seed packaging or empty seedling container IV. Supply wrapping: Plastic films and cardboard. b) Liquid waste I. Obsolete chemical and bio-organic pesticide and fertiliser II. Agricultural machinery and equipment waste: Used lubricant and oil Rice farmers should dispose of properly, through a collection, return, or disposal service as commanded by the irrigation, agriculture, and environmental agencies. To reuse chemical and bio-organic containers for other purposes, rice farmers must obtain permission from this agency.
	Criteria 7: Planting material This criterion intends to use planting material from various agricultural agencies, including rice seed and seedlings. Rice farmers shall use certified seed and seedlings of rice that have been certified by the agriculture authority for planting purposes.	Indicator 1: Pure quality seeds Before use, the rice farmer shall know the seed/seedling quality and maintain records of the variety name, purity, batch number, and vendor. Retain seed certification records if available. Rice farmers shall buy from a small/larger certified provider that has been certified by the agriculture authority.
	Criteria 8: Pest Input Pest inputs refer to the methods and materials used to manage pest populations in rice farming. These include chemical pesticides, biological controls, and cultural practices. The choice of pest management strategy significantly influences species diversity in rice ecosystems. Here is a detailed look at how different pest inputs impact biodiversity and sustainability	Indicator 1: Chemical pesticide Rice farmers shall document the amount of chemical pesticide applied based on the suggestion of the agriculture agency. Farmers shall not add additional amounts of chemical fertiliser without the approval of the agriculture agency.
		Indicator 2: Biological control of pests Rice farmers should have documented the amount of biological pesticide applied, as recommended by the agriculture agency. The documented amount of organic fertiliser shall be kept, indicating rice farmers' contribution to sustainable practices.
	Criteria 9: Fertiliser Input Fertiliser input refers to the amount and type of fertilisers applied to crops, including rice cultivation. It involves	Indicator 1: Inorganic and organic fertilisers The amount of fertiliser (inorganic and/or organic; N, P, and/or K) applied is based on knowledge of soil fertility and expected yield, locally adapted recommendations, and product label instructions (if available).

	determining the appropriate dosage and timing of fertilisers such as nitrogen, phosphorus, and potassium to meet rice plants' nutrient requirements throughout their growth stages. Proper fertiliser use aims to optimise crop yields, improve nutrient-use efficiency, and minimise environmental pollution from excess nutrient runoff. Rice farmers should maximise fertiliser use and encourage the use of organic fertiliser.	Indicator 2: Organic fertiliser Rice farmers should have documented the amount of organic fertiliser applied, as recommended by the agriculture agency. The documented amount of organic fertiliser shall be kept, indicating the rice farmer's contribution to sustainable practices.
Biodiversity	Criteria 10: Species Diversity Species diversity in rice farming refers to the variety and abundance of different species present within the rice ecosystem, including plants, animals, microorganisms, and pests. This diversity plays a crucial role in maintaining the ecological balance and sustainability of rice farming systems.	Indicator 1: Integrated Pest Management (IPM) *a) Weed control* Biological control methods can include: • Good land preparation • Use of certified seeds • Crop rotation • Flooding (if water is abundant) The farmer follows IPM principles and the following criteria: 1. Preventive weed control methods are used before considering curative methods. 2. Herbicides are allowed to be used when curative methods (e.g., manual and mechanical weeding) are not effective on their own, and the severity of the weeds is expected to cause significant damage or loss, based on the suggestion of the agriculture agency. 3. Herbicide selection is in line with agriculture agency recommendations, is registered for use in rice, and comes from a non-counterfeit source. 4. Farmers should be aware and remind the service provider that the herbicide application is targeted to avoid non-application zones as suggested by the agriculture agency. 5. Farmers should be aware and remind service providers that the herbicide application method is according to the product label instructions, follow the specified preharvest intervals, and do not exceed the specified dosage (for worker safety and food safety).

6. Farmers should be aware and remind service providers of herbicide selection and use responses to the target weed species, consider the timing of the closing of the rice canopy, and consider local information on herbicide-resistant weeds (for efficiency).

b) Insect control

Biological control methods can include:

- Balanced nutrient application (e.g., avoid excessive application of nitrogen)
- Promotion of beneficial natural enemies (e.g., insects, spiders) and increasing habitat diversity around rice fields
- Synchronised planting
- Use of resistant/tolerant varieties
- Promotion of other predators (e.g., birds, bats, frogs)
- Crop rotation or extended fallow period

The farmer follows IPM principles and the following criteria:

1. Biological insect control methods are encouraged before considering curative methods
2. Insecticide is used only if other curative methods (e.g., insect pheromones, biological control agents) are not effective on their own, if action thresholds are exceeded, and if the presence of a specific insect is expected to cause significant damage or loss based on the suggestion of the agriculture agency
3. Broad-spectrum insecticide is not used within the first 40 days after planting in the production field (unless in accordance with IPM recommendations given by local government extension experts).
4. Insecticide selection is in line with agriculture agency recommendations, is registered for use in rice, and comes from a non-counterfeit source
5. Farmers should be aware and remind the service provider that the herbicide application is targeted to avoid non-application zones, as suggested by the agriculture agency
6. Farmers should be aware and remind the service provider that the insecticide application method is according to the product label instructions, follows specified preharvest intervals, and does not exceed the specified dosage (for worker safety and food safety).

7. Farmers should be aware and remind service providers of insecticide selection and use responses to the target insect species, consider optimum timing for the target species, and consider local information on insecticide- resistant insects

c) Disease control

Biological control methods can include:

- Effective for fungal, bacterial, and viral diseases
- Balanced nutrient application (e.g., avoid excessive application of nitrogen)
- Planting at optimum densities
- Use of resistant varieties
- Synchronised planting
- Removal of host plants (e.g., weeds on bunds, rice stubble, volunteer rice)
- Keeping the environment between the soil and the plant canopy either dry or moist (depending on the disease)

The farmer follows IPM principles and the following criteria:

1. Preventive disease control methods are used before considering curative methods.
2. Fungicide is used only if other curative methods (e.g., biological control agents) are not effective on their own, and the severity of the disease is expected to cause significant damage or loss, based on the suggestion of the agriculture agency.
3. Fungicide selection is in line with agriculture agency recommendations, is registered for use in rice, and comes from a non-counterfeit source.
4. Farmers should be aware and remind the service provider that the fungicide application is targeted to avoid non-application zones as suggested by the agriculture agency.
5. Farmers should be aware and remind the service provider that the fungicide application method is according to the product label instructions, follows the specified preharvest interval or is at least 30 days before harvest (if the preharvest interval is not available), and does not exceed the specified dosage (for worker safety and food safety).
6. Farmers should be aware and remind service providers of fungicides that correspond to the target disease type, consider the recent history of fungal disease and predicted weather patterns, and consider local information on fungicide-resistant diseases

d) Mollusc control

Biological control methods can include:

- Physical control (e.g., destruction of egg masses)
- Reduction of water level so that snail attack is inhibited during the most vulnerable phase (i.e., early growth phase)
- Promotion of predators (e.g., wild birds, ducks, fish)
- Use of sturdier seedlings during transplanting by sowing low-density nursery beds and planting older seedlings
- Crop rotation or extended dry fallow period

The farmer follows IPM principles and the following criteria:

- Biological disease control methods are encouraged before considering curative methods
- Molluscicide is allowed to be used even if other curative methods (e.g., collection) are not effective on their own, and the severity of the weeds is expected to cause significant damage or loss, based on the suggestion of the agriculture agency.
- Molluscicide selection is in line with agriculture agency recommendations, is registered for use in rice, and comes from a non-counterfeit source.
- Farmers should be aware and remind the service provider that molluscicide application is targeted to avoid non-application zones, as suggested by the agriculture agency.
- Farmers should be aware and remind the service provider that the molluscicide application method is according to the product label instructions, is not used before manual transplanting, follows the specified preharvest interval, and does not exceed the specified dosage (for worker safety and food safety).
- Farmers should be aware and remind the service provider that Molluscicide that corresponds to the target mollusc species is used only within the first 3 weeks after crop establishment.

e) Rodent control

Biological control methods can include:

- Community rodent management (e.g., rat eradication campaigns, trap crops)
- Synchronised planting

			• Use of narrow bunds (to minimise rodent habitat) • Promotion of predators (e.g., birds of prey, snakes) The farmer follows IPM principles and the following criteria: 1. Biological disease control methods are encouraged before considering curative methods 2. Rodenticide is allowed to be used even if other curative methods (e.g., trapping, hunting) are not effective on their own, and the severity of the weeds is expected to cause significant damage or loss, based on the suggestion of the agriculture agency. 3. Rodenticide selection is in line with agriculture agency recommendations, is registered for use in rice, and comes from a non-counterfeit source. 4. Farmers should be aware and remind the service provider that the herbicide application is targeted to avoid non-application zones as suggested by the agriculture agency. 5. Farmers should be aware and remind service providers that the rodenticide application method is according to the product label instructions, follow the specified preharvest intervals, and do not exceed the specified dosage (for worker safety and food safety). 6. Farmers should be aware and remind the service provider that rodenticide that corresponds to the target rodent species is used before the reproductive growth phase of the crop to avoid an outbreak during grain filling, and is placed under protective cover (e.g., bamboo tubes, coconut husks) where not easily accessible to birds or exposed to rainfall f) Bird control Non-lethal bird control methods can include: • Synchronised planting • Scare/deterrent devices • Promotion of predators (e.g., birds of prey, shrikes) • Chemical repellents that do not kill birds and have no adverse side effects
Economic	Transparency	Criteria 11: Traceability This criterion ensures that all rice produced is traceable. For example, rice is traceable to farmers/collection centres/mills.	Indicator 1: Record keeping The farmer shall maintain copies of all relevant documentation and records. Documentation shall include:

	Farmers should track traceability based on their operation. Traceability starts with planting material and continues through post-harvest.	1. Invoices and receipts (purchase, input costs, and sales)
Vulnerability	Criteria 12: Stability of Production Production (quantity and quality) is sufficiently resilient to withstand and be adapted to environmental, social, and economic shocks. A farmer needs to reduce as much as possible the negative impact of production shortages caused by economic, social, and environmental shocks, and to ensure that production volume and quality are met. Some mechanisms ensure that the quantity and quality of production are sufficiently robust to withstand environmental, social, and economic shocks, thereby reducing risks to the farmer's production process, business commitments, and quality standards.	Indicator 1: Guarantee of production levels The farmer has a plan to guarantee the required volume of production and compliance with quality standards in the event of social, environmental and economic shocks. The plan is as follows: • Diversification of rice variety and Income Sources • Access to Financial Instruments and Insurance • Strengthening Social Networks and Collaboration • Digital Tools and Technology Integration • Utilisation of Government and NGO Support Programs
	Criteria 13: Stability of Supply Procurement channels influence the stability of supply, or the ways the farmer obtains the input supplies (e.g., seed, fertilisers, pesticides, agricultural machinery service) required to produce the product(s) to be sold in the market or to offer the core enterprise's service(s) to clients. Ensuring that inputs, goods, and services are delivered on time reduces the farmer's vulnerability and risk exposure to suppliers that might affect the farmer's ability to reach expected production levels or deliver the type and quality of service	Indicator 1: Procurement Channels/ Input Supplies The actions and mechanisms implemented target maintaining business relationships with several suppliers that could guarantee the required input supply. The actions and mechanisms implemented enable access to alternative procurement channels in case current suppliers fail to provide the required inputs. Actions and mechanisms such as below: • Record of Supplier Diversification • Record of Contracts and Agreements • Records of input supply shortages

	offered. Suppliers that maintain a mutually beneficial business relationship with the enterprise over long periods contribute to overall stability. Diversifying the enterprise supply structure helps ensure the capacity and flexibility to address market challenges and reduce the risk of supply defaults.	
	Criteria 14: Liquidity Informal safety nets are equally important as they rely on trust, reciprocity, and social ties, often providing faster and more flexible assistance during emergencies. However, because they are not legally binding, the extent and reliability of support may vary depending on relationships and community capacity. Overall, a farmer's financial resilience relies on their ability to maintain positive cash flow and access both formal and informal safety mechanisms that can be activated during times of stress. Strengthening liquidity management and expanding access to safety nets enhances the farmer's capacity to cope with uncertainties and recover from shocks, contributing to long-term economic sustainability and stability.	Indicator 1: Net Cash Flow Record of positive net cash flow in the last year
		Indicator 2: Safety Nets Access to formal or informal financial sources to withstand liquidity crises
Local Economy	Criteria 15: Value Creation A farmer can support the creation of value in a local economy through fiscal contributions. Fiscal commitment refers to the enterprise's disposition to effectively fulfil its responsibility and obligation as a	Indicator 1: Fiscal Commitment The farmer has paid all applicable local taxes and Zakat due in the countries or states of operation.

		tax contributor by paying the local taxes for which it is eligible. The enterprise's contribution to the local economy, by paying its due taxes at the appropriate time, is a significant component of sustainable development.	
Social	Decent livelihoods of farmer	Criteria 16: Quality of Life Farmers are entitled to a good quality of life, which includes having time for family, rest, recreation, and voluntary overtime, as well as access to education for themselves and their families. A good quality of life also involves the ability to prepare nutritious and culturally fitting meals, and the continued preservation and expression of cultural identity. Culture may be reflected in language, religion, ethnicity, food, clothing, art, traditions, social practices, and other aspects of community life. However, the definition of quality of life varies among individuals and communities, making it difficult to measure with a single indicator. Therefore, quality of life must be assessed using context-specific criteria.	Indicator 1: Right to Quality of Life The rice farmers and their families report that they live free from oppression, in peace and security, and with adequate time for personal and family needs, farmer housing, and education. Many measurable parameters are available; thus, the need to choose based on the assessment's context specification.
		Criteria 17: Capacity Development Farmers have the right to adequate resources to increase their skills and knowledge. Farmers network to identify best practices with neighbours and other farmers in the region, and seek and attend training from extension agents or local non-profits on improved practices.	Indicator 1: Capacity Development Farmers should take opportunities to increase their skills and knowledge as much as possible, offered by the agency, private contractors, and non-profit organizations, through paid or free programs. This ensures farmers can implement their responsibilities for sustainable practices.

	Criteria 17: Capacity Development Farmers have the right to adequate resources to increase their skills and knowledge. Farmer networking to identify best practices with neighbours and other farmers in the region, seek and attend training from extension agents or local non-profits on improved practices.	Indicator 1: Capacity Development Farmers should take opportunities to increase their skills and knowledge as much as possible, offered by the agency, private contractors, and non-profit organizations, through paid or free programs. This ensures farmers can implement their responsibilities for sustainable practices.
	Criteria 18: Right to use land Rice cultivation by rice farmers shall not diminish the rights of other users. A rice farmer/ entrepreneur must present their right to use the land.	Indicator 1: Proof of ownership Proof of ownership or rights to use land, such as land title, lease, or joint venture agreement with indigenous peoples, family, and other rice farmer landowners (if available), shall be made available to relevant stakeholders upon request.
Labour right	Criteria 19: Employment condition Respecting human rights is paramount to ensuring a good relationship between farmers and workers. Specific attention to young people at work will enable them to develop their full potential. This criterion shall be embedded and implemented by rice farmers "(if they hire a worker or contractor)."	Indicator 1: Employment relations Should the farmer have written agreements with their worker or contractor that at least meet national and international labour treaties, including social security, or at least have a clear understanding based on a verbal agreement between the employer and employees? A contract of service, also known as a contract of employment or employment contract, is a written agreement between an employer and an employee that, together with the rights of each under statute and common law, determines the employment relationship between them.
		Indicator 2: Forced labour There is no forced, compulsory, or slave labour used, including trafficked and bonded labour, labour by prisoners, or the use of extortion, debt, threats, fines, or penalties. The following criteria are met: 1. No withholding of (part of) the worker's salary, benefits, property, or documents (e.g., identity cards and travel documents) to force such worker to continue to work. 2. Workers are not charged recruiting or hiring fees that require them to be indebted to the farm (or recruiting agency). 3. Workers are allowed to leave the farm's premises at the end of their shifts. 4. Regular working hours of workers do not exceed 48 hours per week, with at least one full day of rest for every six consecutive days worked.

5. Spouses and children of contracted workers are not forced to work on the farm.6.
6. The farmer does not participate in or allow human trafficking.

Indicator 3: Discrimination

There is no discrimination or disrespectful treatment of workers, including working household members. The following criteria are met:

1. No discrimination based on gender, ethnic background, national origin, religion, disability, sexual orientation, pregnancy, worker organisation membership, or political affiliation.
2. No distinction, exclusion, or preference to harm equality of opportunity in hiring, training, task assignment, benefits, remuneration, advancement, termination, retirement, or other employment-related decisions.
3. No job-related medical testing as a condition of employment (except lawful drug testing).
4. No behaviour, gesture, language, or physical contact that is sexually abusive, coercive, or threatening.
5. No bullying or physical punishment

Indicator 4: Child labour

Children under 15 years of age are not engaged as workers. Family members below 15 years of age living on family farms may participate in farming activities that consist of light, age-appropriate duties that allow them to develop skills, only if the activities are:

1. Not harmful to their health and development.
2. Do not interfere with schooling and leisure time.
3. Under the supervision of an adult.
4. Not above 14 hours a week.
5. Children living on the farm in the age of compulsory schooling go to school all year long

Indicator 5: Wages

The following criteria are met:

1. Wages of workers meet or exceed the legal minimum wage required under local or national laws and regulations. If wages are negotiated voluntarily between employers and workers' associations, the negotiated wage amount(s) apply to all workers covered under the

			negotiated agreement. This includes providing equal pay for work of equal value to men and women. 2. Wages are paid promptly and regularly. 3. Wages are paid in a legal currency or another form acceptable to workers without creating any form of dependency. 4. Overtime is voluntary and is paid at the rate required by local or national laws and regulations, or as collectively negotiated Pay slips should contain, at a minimum, the following information: • Number of working days; Working days on rest days/public holidays. • Rate of pay – typical/rest day/public holiday; Overtime rate and hours; and Deductions. • Copies of pay slips should be provided to employees
			Indicator 6: Freedom of Association Workers have the right to establish and/or join an association of their choice without interference and take part in collective bargaining on working conditions. The following criteria are met: 1. Workers can freely establish and join workers' organisations, both internal (e.g., workers' representations) and external (e.g., trade unions), and take part in collective bargaining on working conditions. 2. The effective functioning of labour organisations is not blocked, and representatives of such organisations are not discriminated against.
	Human safety & health	Criteria 20: Workplace safety This criterion aims to prevent injury and ill health and to enhance the work environment for rice farmers. This criterion is based on rice farmers' capabilities; if they implement it, it should be recorded as a contribution to social sustainability.	Indicator 1: Safety Instruction and First Aid Farmers and workers, including working household members, receive regular safety instructions on how to prevent work-related accidents or diseases, where to access first-aid kits, and how to contact health workers, as included in Hazard Identification, Risk Assessment, and Risk Control (HIRARC). The first aid kit should be well-labelled, updated with its items, and available on-farm or placed at a designated medical centre known by and accessible to farmers in a farm community group.
			Indicator 2: Tools and equipment Tools and equipment for farm operations and postharvest processes are kept working and efficient through regular and proper maintenance and calibration. Tools are adequately stored.

	Pesticide application equipment (if pesticide(s) are applied) is maintained and calibrated to prevent leakage or contamination.
	Indicator 3: Training of pesticide applicators Pesticide applicators should be trained, aware, and apply good practices on the safe handling and use of pesticides by rice farmers if they hire their own personal worker, including: 1. An explanation of the names, toxicity, health risks, and other relevant information related to all substances to be applied. 2. Techniques for the correct handling of substances. 3. Preventive measures for reducing possible damage to health and the environment caused by substances.
	Indicator 4: Personal protective equipment (PPE) • Pesticide applicators use functional and good-quality PPE as recommended on the product label, including: • Chemical-resistant gloves • Masks • Dermal protection (e.g., long-sleeved shirt, long-trouser legs) • Boots • Eye protection during mixing and application
	Indicator 5: Washing and changing Designated areas for washing PPE, bathing, and changing are available for pesticide applicators after finishing the application. All PPE worn during pesticide application
	Indicator 6: Applicator restrictions Pesticides are not applied by pregnant or lactating women, by persons below 18 years, or by persons who suffer from chronic or respiratory diseases.
	Indicator 7: Re-entry time Re-entry time after the use of pesticides: 1. Follow the recommendation on the product label, or after 48 hours if the label does not give a recommendation. 2. Is communicated.

4.3.2 Finalised Sustainability Sub-Indicator Under Criteria and Dimensions

On the finalised sustainability sub-indicators, adapted from past literature, and on the creation of questions to make them sub-indicators. Fifty-eight sub-indicators have been used as assessment variables in the development index. However, only 53 sub-indicators were used to assess rice farmers, as 5 were deemed unsuitable for this purpose based on feedback from the agriculture officer. The finalised sustainability criteria were categorised into three main pillars: environmental, economic, and social. The structure of the criteria and indicators comprises three dimensions, three principles, 12 elements, 20 criteria, and 34 indicators. A full description of the criteria and their indicators is presented in Table 4.3, with 5 sub-indicators highlighted in yellow and eliminated.

Table 4.3
Summary of Review of Sustainability Criteria and Indicators

Dimension	Element	Criteria	Indicator	Sub-indicator
Environmental	Air	Zero burning practices	Rice Stubble and Rice Straw	Use of decaying material
				Burning
				Use of plough
				Use for by-product
	Water	Water resources	Water management	Timely crop establishment
				Flood-tolerant variety
				Dry-tolerant variety
				Alternate Wetting and Drying (AWD)
				Groundwater extraction
				Informed water irrigation issue
	Land	Pre-planting	Land Suitability	Concern form
			Surveillance of Rice Field	Irrigation and Drainage System Functionality, Maintenance of field bunds (batas), Farm Road.
			Land preparation	Land preparation schedule, empty field, and field supervision.
		Harvesting and post-harvesting	Timing of harvest	Drying and stalk visualisation
			Harvesting equipment	Maintenance of harvesting equipment
			Post-harvest handling	Transport storage, 24-hour yield transfer timeframe, and representative of selling yield
	Material And Energy	Efficiency of energy use	Non-renewable energy consumption	Use of diesel
				Use of Gasoline/ Petrol
			Mechanism of	Use of service provider

			action for reducing non-renewable energy consumption	
		Waste management and disposal	Waste management standard operating procedure	Waste management hierarchy of control
			Farm operational disposal	Solid and liquid waste of agricultural machinery and equipment
				Reuse of chemical and bio-organic containers
		Planting material	Pure quality seed	Receive seed from a certified seed provider
		Pest Input	Chemical pesticide	Amount of chemical pesticide consumption
			Organic pesticide	Amount of Organic pesticide (Natural ingredients)
		Fertilizer Input	Chemical fertilizer	Amount of chemical fertilizer consumption
			Organic fertilizer	Amount of biological fertilizer consumption
	Biodiversity	Species Diversity	Integrated Pest Management (IPM)	Weed management
				Insect management
				Disease management
				Mollusc management
				Rodent management
				Bird management
Economic	Transparency	Traceability	Record keeping	Input cost per year
				Yield per year
	Vulnerability	Stability of Production	Guarantee of production levels	Diversification of rice variety
				Diversification of income
				Access to Financial Instruments and Insurance
				Social Networks and Collaboration
				Digital Tools and Technology Integration
				Utilisation of Government and NGO Support Programs
		Stability of Supply	Procurement Channels/ Input Supplies	Record of Supplier Diversification
				Record of Contracts and Agreements
				Records of input supply shortages
		Liquidity	Net Cash Flow	Record of positive net cash flow in the five (5) year
			Safety Nets	Formal or informal financial sources to withstand liquidity crises
	Local economy	Value Creation	Fiscal Commitment	local taxes and Zakat
Social	Decent livelihoods	Quality of Life	Right to Quality of Life	Wellbeing status

of farmer	Capacity Development	Capacity Development	Rice Farmers' Capacity Level
	Right to use land	Proof of ownership	Land ownership rights
Labour right	Employment condition	Employment relations	Employment contract
Human safety & health	Workplace safety	Safety Instruction and first aid	Safety Instruction and first aid
		Tools and equipment	Tools and equipment
		Training of pesticide applicators	Training of pesticide applicators
		Personal protective equipment (PPE)	Personal protective equipment (PPE)
		Washing and changing	Washing and changing
		Applicator restrictions	Applicator restrictions
		Re-entry time	Re-entry time

4.4 Assessment and Development of Malaysian Sustainable Rice Index (MySRI)

This section presents the findings of the assessment and index development. The first finding presented the respondents' profile in relation to the sustainability score. Second, on the index development, the list of dimensions, elements, criteria, indicators, sub-indicators, symbols, units, and standard or threshold values was presented. The data had different units and scales. Proximity-to-target (PTT) and categorical scale normalisation techniques were presented, followed by the criteria, dimension, and overall index.

4.4.1 Profile of The Respondents

As mentioned in the methodology chapter, the respondents of this study were rice farmers under the supervision of IADA BLS. IADA BLS suggested selecting rice farmers who are relevant and can answer and provide assessment data. Table 4.4 presents the demographic characteristics of rice farmers.

Table 4.4
Rice Farmer Demographic

Age	Frequency	Percentage (%)

20-29	7	15.56
30-39	10	22.22
40-49	11	24.44
50-59	11	24.44
60-69	5	11.11
70-79	1	2.22
80-89	0	0.00
Total	45	100.00
Gender		
Male	45	100.00
Female	0	0
Total	45	100.0
Ethnicity		
Malay	40	88.88
Indian	0	0
Chinese's	5	11.11
Total	45	100.00
Education		
Primary	3	6.66
SRP	8	17.77
LCE	0	0
SPM	30	66.66
MCE	0	0
STPM	0	0
HCE	0	0
Diploma	2	4.44
Bachelor's degree	0	0
Master's degree	0	0
PhD	0	0
Professional Qualification	2	4.44
Total	45	100.00
Rice land status		
Mixed owned	23	51.11
Owned	0	0
Rented	22	48.89
Total	45	100.00

The MySRI assessment score revealed a moderate-to-best sustainability level among rice farmers. The majority of the respondents scored above 70%, indicating exemplary implementation of sustainable practices. Four rice farmers received over 90% sustainability scores, while only two scored below 55%, indicating that unsustainable practices persist. The level of education indicates that 30 rice farmers with the Sijil Pelajaran Malaysia have a sustainability score over 60%. This shows that the middle level of education attracts rice farmers to adopt sustainable practices. The younger farmers under 40 showed moderate to high sustainability scores for about 17 of them, indicating increased adoption of sustainable practices.

4.4.2 Development of the Malaysian Sustainable Rice Index (MySRI)

Index development began with a table listing dimensions, elements, criteria, indicators, sub-indicators, symbols, units, and standard or threshold values. The sub-indicator data value conversion was done on a scale of 1, 2, 3, 4, and 5 to points 20, 40, 60, 80, and 100. Weighting was performed using equal weighting. Then, normalisation was performed on the created table. The calculation of the criteria, dimensions, and overall index values was completed. This component was created and calculated following the index formula using Microsoft Excel.

4.4.2.1 List of Dimension Element Criteria, Indicator, Sub-Indicator, Symbol, Unit and Standard or Threshold Value

The findings of this component assessment were conducted on objectives 1 and 2. To reduce the amount of wording, the criteria, indicators, sub-indicators, and components were symbolised, as shown in Table 4.5. However, several sub-indicators have been eliminated from the assessment because they were found unsuitable for assessing rice farmers in IADA BLS. These sub-indicators are Flood-tolerant variety, Dry-tolerant variety, Alternate Wetting and Drying (AWD), Groundwater extraction, and Reuse of chemical and bio-organic containers.

4.4.2.2 Weighting

An equal-weighting technique was used to develop the index for each proposed sustainability criterion. Thus, 100% divided by the total number of dimensions resulted in 33.33% for each dimension. There were 10 criteria under the environmental dimensions, divided into 33.33% each, yielding 3.33% for each criterion. The five economic dimensions were divided equally, with 33.33% allocated to each, yielding 6.66% for each criterion. Lastly, the five social dimensions were divided, with 33.33% allocated to each, yielding 6.66% per criterion. The weighting percentages for the criteria along their dimensions are shown in Figure 4.1 below.

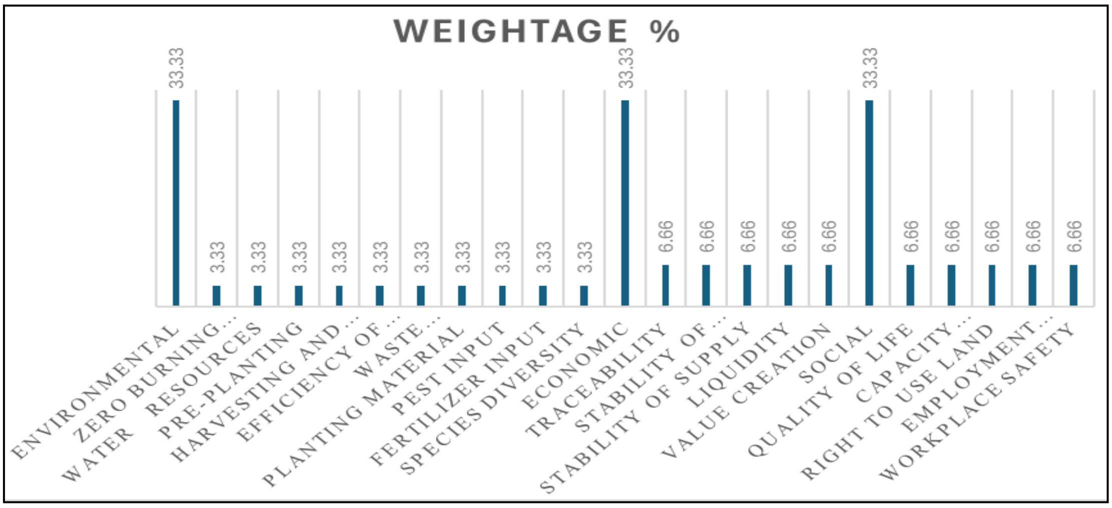


Figure 4.1 Summary of Criteria Weightage Distribution (Created by Researcher)

Table 4.5
Summary of Review of Sustainability Criteria and Indicators

	Dimension	Element	Criteria	Indicator	Sub-indicator Symbol	Unit	Standard/ threshold value	Normalisation Technique	Type A or B
Malaysian Sustainable Rice Index (MySRI)	Environment	Air	Zero burning practices	Rice Stubble and straw	EVC1I1Sb1	Scale	40-60 points	Categorical	A
					EVC1I1Sb2	Scale	40-60 points	Categorical	A
					EVC1I1Sb3	Scale	40-60 points	Categorical	A
					EVC1I1Sb4	Scale	40-60 points	Categorical	A
		Water	Water resources	Water management	EVC2I2Sb1	Scale	40-60 points	Categorical	A
					EVC2I2Sb2	Scale	40-60 points	Categorical	A
		Land	Pre-planting	Land Suitability	EVC3I3Sb1	Scale	40-60 points	Categorical	A
				Surveillance of Rice Field	EVC3I4Sb1	Scale	40-60 points	Categorical	A
				Land preparation	EVC3I5Sb1	Scale	40-60 points	Categorical	A
		Harvesting and post-harvesting	Timing of harvest	Timing of harvest	EVC4I6Sb1	Scale	40-60 points	Categorical	A
				Harvesting equipment	EVC4I7Sb1	Scale	40-60 points	Categorical	A
				Post-harvest handling	EVC4I8Sb1	Scale	40-60 points	Categorical	A
		Material and Energy	Efficiency of energy use	Non-renewable energy consumption	EVC5I9Sb1	MYR	Mean	PTT	B
					EVC5I9Sb2	MYR	Mean	PTT	B
				Mechanism of action for reducing non-renewable energy consumption	EVC5I10Sb1	Scale	40-60 points	Categorical	A
			Waste management and disposal	Waste management standard operating procedure	EVC6I11Sb1	Scale	40-60 points	Categorical	A
				Farm operational disposal	EVC6I12Sb1	Scale	40-60 points	Categorical	A
			Planting material	Pure quality seed	EVC7I13Sb1	Scale	40-60 points	Categorical	A
			Pest Input	Chemical and organic pesticide	EVC8I14Sb1	MYR	Mean	PTT	B
					EVC8I14Sb2	MYR	Mean	PTT	A
			Fertilizer Input	Chemical and biological fertilisers	EVC9I15Sb1	MYR	Mean	PTT	B
					EVC9I15Sb2	MYR	Mean	PTT	A
		Biodiversity	Species Diversity	Integrated Pest Management (IPM)	EVC10I16Sb1	Scale	40-60 points	Categorical	A
					EVC10I16Sb2	Scale	40-60 points	Categorical	A

				EVC10I16Sb3	Scale	40-60 points	Categorical	A
				EVC10I16Sb4	Scale	40-60 points	Categorical	A
				EVC10I16Sb5	Scale	40-60 points	Categorical	A
				EVC10I16Sb6	Scale	40-60 points	Categorical	A
Economy	Transparency	Traceability	Record keeping	ECC11I17Sb1	MYR	Mean	PTT	B
				ECC11I17Sb2	MYR	Mean	PTT	A
	Vulnerability	Stability of Production	Guarantee of production levels	ECC12I18Sb1	Scale	40-60 points	Categorical	A
				ECC12I18Sb2	Scale	40-60 points	Categorical	A
				ECC12I18Sb3	Scale	40-60 points	Categorical	A
				ECC12I18Sb4	Scale	40-60 points	Categorical	A
				ECC12I18Sb5	Scale	40-60 points	Categorical	A
				ECC12I18Sb6	Scale	40-60 points	Categorical	A
		Stability of Supply	Procurement Channels/ Input Supplies	ECC13I19Sb1	Scale	40-60 points	Categorical	A
				ECC13I19Sb2	Scale	40-60 points	Categorical	A
				ECC13I19Sb3	Scale	40-60 points	Categorical	A
		Liquidity	Net Cash Flow	ECC14I20Sb1	Scale	40-60 points	Categorical	A
			Safety Nets	ECC14I21Sb2	Scale	40-60 points	Categorical	A
	Local economy	Value Creation	Fiscal Commitment	ECC15I22Sb1	Scale	40-60 points	Categorical	A
Social	Decent livelihoods of farmer	Quality of Life	Right to Quality of Life	ESC16I23Sb1	Scale	40-60 points	Categorical	A
		Capacity Development	Capacity Development	ESC17I24Sb1	Scale	40-60 points	Categorical	A
		Right to use land	Right to use land	ESC18I25Sb1	Scale	40-60 points	Categorical	A
	Labour right	Employment condition	Employment relations	ESC19I26Sb1	Scale	40-60 points	Categorical scale	A
	Human safety & health	Workplace safety	Safety Instruction and First Aid	ESC20I27Sb1	Scale	40-60 points	Categorical	A
			Tools and equipment	ESC20I27Sb2	Scale	40-60 points	Categorical	A
			Training of pesticide applicators	ESC20I27Sb3	Scale	40-60 points	Categorical	A
			Personal protective equipment (PPE)	ESC20I27Sb4	Scale	40-60 points	Categorical	A
			Washing and changing	ESC20I27Sb5	Scale	40-60 points	Categorical	A
			Applicator restrictions	ESC20I27Sb6	Scale	40-60 points	Categorical	A
			Re-entry time	ESC20I27Sb7	Scale	40-60 points	Categorical	A

4.4.2.3 Normalisation of Sub-Indicators

Proximity to target (PTT) and the categorical scale formula were used in this step. Sub-indicators under the PTT normalisation technique used type A or B. The categorical scale score was directly given to the sub-indicator. The calculation ranges from 0 to 100. 100 indicates the farmer achieved the sub-indicator target, while 0 indicates poor performance. Table 4.6 shows the normalisation results based on the PTT and categorical scale for five rice farmers; the other 40 rice farmers are presented in the **APPENDIX 15A**.

Table 4.6
Normalisation Results for Each of the Rice Farmers.

Malaysian Sustainable Rice Index (MySRI)					Farmer				
		Criteria	**Indicator**	**Sub-indicator**	**1**	**2**	**3**	**4**	**5**
Dimension	**Environment**	Zero burning practices	Rice Stubble and straw	EVC1I1Sb1	60	20	20	60	20
				EVC1I1Sb2	100	100	100	60	80
				EVC1I1Sb3	80	80	80	60	80
				EVC1I1Sb4	60	60	60	60	20
		Water resources	Water management	EVC2I2Sb1	100	100	100	100	100
				EVC2I2Sb2	80	60	60	80	80
		Pre-planting	Land Suitability	EVC3I3Sb1	100	40	40	60	100
			Surveillance of Rice Field	EVC3I4Sb1	100	100	100	100	80
			Land preparation	EVC3I5Sb1	100	100	100	100	80
		Timing of harvest	Timing of harvest	EVC4I6Sb1	100	100	100	100	100
			Harvesting equipment	EVC4I7Sb1	100	100	100	60	80
			Post-harvest handling	EVC4I8Sb1	100	100	100	100	100
		Efficiency of energy use	Non-renewable energy consumption	EVC5I9Sb1	100	82	82	98	78
				EVC5I9Sb2	42	100	100	79	79
			Mechanism of action for reducing non-renewable energy consumption	EVC5I10Sb1	100	100	100	100	80
		Waste management and disposal	Waste management standard operating procedure	EVC6I11Sb1	80	20	20	60	20

		Farm operational disposal	EVC6I12Sb1	100	80	80	100	40
	Planting material	Pure quality seed	EVC7I13Sb1	100	100	100	100	100
	Pest Input	Chemical pesticide	EVC8I14Sb1	0	19	19	59	0
		Organic pesticide	EVC8I14Sb2	0	0	0	0	0
	Fertilizer Input	Chemical fertilizer	EVC9I15Sb1	81	48	48	100	72
		Biological fertilizer	EVC9I15Sb2	0	100	100	0	0
	Species Diversity	Integrated Pest Management (IPM)	EVC10I16Sb1	100	100	100	100	100
			EVC10I16Sb2	100	100	100	100	100
			EVC10I16Sb3	100	100	100	100	100
			EVC10I16Sb4	100	100	100	60	80
			EVC10I16Sb5	100	100	100	100	100
			EVC10I16Sb6	60	60	60	60	60
Economy	Traceability	Record keeping	ECC11I17Sb1	100	54	54	100	97
			ECC11I17Sb2	86	100	100	91	0
	Stability of Production	Guarantee of production levels	ECC12I18Sb1	60	100	100	80	40
			ECC12I18Sb2	20	20	20	20	20
			ECC12I18Sb3	80	100	100	60	80
			ECC12I18Sb4	100	100	100	60	100
			ECC12I18Sb5	60	80	80	80	100
			ECC12I18Sb6	100	100	100	100	100
	Stability of Supply	Procurement Channels/ Input Supplies	ECC13I19Sb1	100	60	60	80	60
			ECC13I19Sb2	20	20	20	40	20
			ECC13I19Sb3	80	100	100	60	60
	Liquidity	Net Cash Flow	ECC14I20Sb1	60	60	60	20	20
		Safety Nets	ECC14I21Sb2	100	40	40	60	20
	Value Creation	Fiscal Commitment	ECC15I22Sb1	100	100	100	100	100
Social	Quality of Life	Right to Quality of Life	ESC16I23Sb1	100	60	60	100	60
	Capacity Development	Capacity Development	ESC17I24Sb1	60	60	60	80	60
	Right to use land	Right to use land	ESC18I25Sb1	100	100	100	60	100
	Employment condition	Employment relations	ESC19I26Sb1	80	80	80	80	80
	Workplace safety	Safety Instruction and First Aid	ESC20I27Sb1	60	60	60	60	60
		Tools and equipment	ESC20I27Sb2	100	100	100	100	100
		Training of pesticide applicators	ESC20I27Sb3	100	100	100	100	80

	Personal protective equipment (PPE)	ESC20I27Sb4	100	80	80	100	100
	Washing and changing	ESC20I27Sb5	80	60	60	100	100
	Applicator restrictions	ESC20I27Sb6	100	100	100	100	100
	Re-entry time	ESC20I27Sb7	60	100	100	100	100

4.4.2.4 Aggregation Score

After obtaining the normalisation score in Table 4.7, the aggregation calculation was performed, starting with the calculation of the criteria score. C_{jk} and the criteria aggregation score CAS_{jk} using the existing formula presented in Table 3.18. The result in Table 4.7 only presented 5 farmers; the remaining farmers' results are presented in **APPENDIX 16A.**

Table 4.7
Criteria, Criteria Aggregation and Weightage Score of The Rice Farmer.

Criteria	**Criteria Score**					**Weightage**	**Criteria Aggregation score**				
	Farmer						**Farmer**				
	1	**2**	**3**	**4**	**5**		**1**	**2**	**3**	**4**	**5**
Zero burning practices	75	65	65	60	50	3.33%	2.50	2.16	2.16	2.00	1.67
Water resources	90	80	80	90	90	3.33%	3.00	2.66	2.66	3.00	3.00
Pre-planting	100	80	80	87	87	3.33%	3.33	2.66	2.66	2.89	2.89
Harvesting and post-harvesting	100	100	100	87	93	3.33%	3.33	3.33	3.33	2.89	3.11
Efficiency of energy use	81	94	94	92	79	3.33%	2.69	3.13	3.13	3.07	2.63
Waste management and disposal	90	50	50	80	30	3.33%	3.00	1.67	1.67	2.66	1.00
Planting material	100	100	100	100	100	3.33%	3.33	3.33	3.33	3.33	3.33
Pest Input	0	9	9	30	0	3.33%	0.00	0.31	0.31	0.99	0.00
Fertilizer Input	93	77	77	96	49	3.33%	3.09	2.56	2.56	3.18	1.62
Species Diversity	93	93	93	87	90	3.33%	3.11	3.11	3.11	2.89	3.00
Traceability	93	77	77	96	49	6.66%	6.18	5.13	5.13	6.37	3.24
Stability of Production	70	83	83	67	73	6.66%	4.66	5.55	5.55	4.44	4.88
Stability of Supply	67	60	60	60	47	6.66%	4.44	4.00	4.00	4.00	3.11
Liquidity	80	50	50	40	20	6.66%	5.33	3.33	3.33	2.66	1.33
Value Creation	100	100	100	100	100	6.66%	6.66	6.66	6.66	6.66	6.66
Quality of Life	100	60	60	100	60	6.66%	6.66	4.00	4.00	6.66	4.00
Capacity Development	60	60	60	80	60	6.66%	4.00	4.00	4.00	5.33	4.00

Right to use land	100	100	100	60	100	6.66%	6.66	6.66	6.66	4.00	6.66
Employment condition	80	80	80	80	80	6.66%	5.33	5.33	5.33	5.33	5.33
Workplace safety	86	86	86	94	91	6.66%	5.71	5.71	5.71	6.28	6.09

Next, the calculation of the dimension D_{jI} and overall index Ij using the adapted formula. The majority of rice farmers showed high dimension and overall index values, but 2 farmers scored between 40% and 60%, indicating the need for improvement in their agricultural practices. Table 4.8 presents the results of the dimension and index scores.

Table 4.8
Result of Dimensions and Index Score

Rice farmer	**Dimension score**			**Index, Ij**
	Environment	Economic	Social	
Farmer 1	27.37	27.27	28.35	82.99
Farmer 2	24.93	24.66	25.69	75.29
Farmer 3	24.93	24.66	25.69	75.29
Farmer 4	26.89	24.13	27.59	78.61
Farmer 5	22.23	19.22	26.07	67.52
Farmer 6	29.22	31.27	31.78	92.27
Farmer 7	29.46	25.40	30.07	84.93
Farmer 8	27.68	26.39	28.16	82.23
Farmer 9	27.27	22.22	27.59	77.08
Farmer 10	28.41	26.00	28.73	83.14
Farmer 11	26.58	28.42	27.97	82.97
Farmer 12	26.58	28.42	27.97	82.97
Farmer 13	29.34	29.35	31.02	89.71
Farmer 14	29.28	29.57	31.02	89.86
Farmer 15	28.25	29.30	32.54	90.09
Farmer 16	28.69	29.08	26.64	84.42
Farmer 17	28.03	28.42	26.64	83.08
Farmer 18	25.53	28.42	29.30	83.25
Farmer 19	26.84	26.32	23.60	76.75
Farmer 20	23.35	25.53	24.36	73.23
Farmer 21	26.18	25.97	25.69	77.85
Farmer 22	27.68	26.85	27.21	81.75
Farmer 23	24.98	26.64	28.73	80.35
Farmer 24	24.62	27.72	27.40	79.74
Farmer 25	26.69	26.32	23.79	76.80
Farmer 26	22.98	25.24	25.69	73.90
Farmer 27	25.87	25.90	25.69	77.46
Farmer 28	28.01	25.61	28.16	81.79
Farmer 29	17.36	13.41	22.26	53.04
Farmer 30	18.44	17.87	22.45	58.76
Farmer 31	25.88	26.18	28.73	80.79

Farmer 32	25.73	26.05	27.78	79.56
Farmer 33	24.29	26.42	28.54	79.25
Farmer 34	25.16	20.36	27.40	72.93
Farmer 35	30.49	27.56	29.49	87.54
Farmer 36	25.39	21.09	28.73	75.21
Farmer 37	24.71	27.79	27.02	79.52
Farmer 38	25.12	20.88	26.07	72.08
Farmer 39	25.01	20.88	24.74	70.63
Farmer 40	26.84	27.53	28.16	82.53
Farmer 41	31.25	23.87	29.30	84.42
Farmer 42	31.14	27.08	27.21	85.43
Farmer 43	26.16	23.68	16.75	66.59
Farmer 44	25.11	20.57	25.50	71.18
Farmer 45	28.40	20.22	27.02	75.64

4.4.2.5 Result of Interpretation

Based on the index scores, dimensions, criteria, and indicators calculated in sub-sections 4.4.2.2 to 4.4.2.4, the results are summarised as follows. The performance of MySRI for each rice farmer was assessed using 58 sub-indicators across 10 criteria: the environment, five for the economy, and five for the social. Table 4.12 presents the performance ratings based on the scores obtained by five rice farmers, according to the guidelines in Table 3.15. Using this rating facilitates comparison between rice farmers. For sub-indicators below 40% of this rating, improvements to rice farmers' agricultural practices are required. Analysis by dimensions, criteria, and indicators has identified critical weaknesses for addressing. Table 4.9 shows that all farmers received a good overall score, exceeding the 40% threshold required to maintain it. Nevertheless, in the economic dimension, rice farmer 29 was found to be below the threshold value. Thus, the rice farmer's value was proposed to be increased to 40% or above.

Table 4.9
Sustainability Performance Rating of Rice Farmers.

Farmer	**MySRI**		**Dimension**								
			Environment			**Economy**			**Social**		
	Score %	**Rating**	**Score**	**%**	**Rating**	**Score**	**%**	**Rating**	**Score**	**%**	**Rating**
Farmer1	82.99	5	27.37	82.12	5	27.27	81.82	5	28.35	85.07	5
Farmer2	75.29	4	24.93	74.81	4	24.66	74.00	4	25.69	77.07	4
Farmer3	75.29	4	24.93	74.81	4	24.66	74.00	4	25.69	77.07	4
Farmer4	78.61	4	26.89	80.68	5	24.13	72.39	4	27.59	82.78	5
Farmer5	67.52	4	22.23	66.70	4	19.22	57.67	3	26.07	78.22	4
Farmer6	92.27	5	29.22	87.67	5	31.27	93.83	5	31.78	95.34	5
Farmer7	84.93	5	29.46	88.40	5	25.40	76.20	4	30.07	90.20	5

Farmer8	82.23	5	27.68	83.05	5	26.39	79.17	4	28.16	84.50	5
Farmer9	77.08	4	27.27	81.82	5	22.22	66.67	4	27.59	82.78	5
Farmer10	83.14	5	28.41	85.23	5	26.00	78.01	4	28.73	86.21	5
Farmer11	82.97	5	26.58	79.76	4	28.42	85.26	5	27.97	83.92	5
Farmer12	82.97	5	26.58	79.76	4	28.42	85.26	5	27.97	83.92	5
Farmer13	89.71	5	29.34	88.04	5	29.35	88.06	5	31.02	93.06	5
Farmer14	89.86	5	29.28	87.84	5	29.57	88.72	5	31.02	93.06	5
Farmer15	90.09	5	28.25	84.76	5	29.30	87.92	5	32.54	97.63	5
Farmer16	84.42	5	28.69	86.09	5	29.08	87.25	5	26.64	79.93	4
Farmer17	83.08	5	28.03	84.09	5	28.42	85.26	5	26.64	79.93	4
Farmer18	83.25	5	25.53	76.60	4	28.42	85.26	5	29.30	87.92	5
Farmer19	76.75	4	26.84	80.51	5	26.32	78.98	4	23.60	70.79	4
Farmer20	73.23	4	23.35	70.04	4	25.53	76.60	4	24.36	73.08	4
Farmer21	77.85	4	26.18	78.56	4	25.97	77.93	4	25.69	77.07	4
Farmer22	81.75	5	27.68	83.06	5	26.85	80.57	5	27.21	81.64	5
Farmer23	80.35	5	24.98	74.93	4	26.64	79.93	4	28.73	86.21	5
Farmer24	79.74	4	24.62	73.87	4	27.72	83.17	5	27.40	82.21	5
Farmer25	76.80	4	26.69	80.09	5	26.32	78.98	4	23.79	71.36	4
Farmer26	73.90	4	22.98	68.94	4	25.24	75.72	4	25.69	77.07	4
Farmer27	77.46	4	25.87	77.63	4	25.90	77.72	4	25.69	77.07	4
Farmer28	81.79	5	28.01	84.05	5	25.61	76.85	4	28.16	84.50	5
Farmer29	53.04	3	17.36	52.10	3	13.41	40.23	3	22.26	66.80	4
Farmer30	58.76	3	18.44	55.32	3	17.87	53.60	3	22.45	67.37	4
Farmer31	80.79	5	25.88	77.65	4	26.18	78.55	4	28.73	86.21	5
Farmer32	79.56	4	25.73	77.21	4	26.05	78.15	4	27.78	83.35	5
Farmer33	79.25	4	24.29	72.87	4	26.42	79.26	4	28.54	85.64	5
Farmer34	72.93	4	25.16	75.49	4	20.36	61.10	4	27.40	82.21	5
Farmer35	87.54	5	30.49	91.47	5	27.56	82.69	5	29.49	88.49	5
Farmer36	75.21	4	25.39	76.17	4	21.09	63.28	4	28.73	86.21	5
Farmer37	79.52	4	24.71	74.14	4	27.79	83.37	5	27.02	81.07	5
Farmer38	72.08	4	25.12	75.38	4	20.88	62.66	4	26.07	78.22	4
Farmer39	70.63	4	25.01	75.05	4	20.88	62.66	4	24.74	74.22	4
Farmer40	82.53	5	26.84	80.53	5	27.53	82.59	5	28.16	84.50	5
Farmer41	84.42	5	31.25	93.76	5	23.87	71.62	4	29.30	87.92	5
Farmer42	85.43	5	31.14	93.42	5	27.08	81.26	5	27.21	81.64	5
Farmer43	66.59	4	26.16	78.49	4	23.68	71.06	4	16.75	50.24	3
Farmer44	71.18	4	25.11	75.33	4	20.57	61.73	4	25.50	76.50	4
Farmer45	75.64	4	28.40	85.20	5	20.22	60.66	4	27.02	81.07	5

Additionally, the MySRI results presented scores for each block under IADA BLS supervision. The results show that all blocks in the IADA BLS network exceeded the threshold, and each block is ranked in Table 4.10.

Table 4.10
Overall Rank Sustainability Performance Under Each Block.

Rank	**Block**	**MySRI**		**Dimension**					
				Environment		**Economic**		**Social**	
		Score %	**Rating**	**Score %**	**Rating**	**Score %**	**Rating**	**Score %**	**Rating**
1	Pasir Panjang	87.90	5	89.56	5	83.52	5	90.66	5
2	Sungai Leman	83.23	5	83.36	5	83.68	5	82.67	5
3	Sungai Nipah	81.64	5	81.68	5	81.92	5	84.27	5
4	Sungai Panjang	80.84	5	81.57	5	76.82	4	84.15	5
5	Sungai Burong	78.63	4	77.66	4	78.78	4	79.47	4
6	Sawah	77.96	4	76.96	4	72.90	4	84.04	5

7	Sempadan Panchang Bedena	77.59	4	78.88	4	71.82	4	82.10	5
8	Bagan Terap	72.04	4	75.62	4	68.25	4	72.28	4
9	Sekinchan	67.12	4	65.42	4	63.69	4	72.28	4

Overall, rice farmers' MySRI score in the Integrated Agriculture Development Area (IADA) shows high levels of sustainability performance. This indicates that rice farmers practised sustainable agricultural practices in the cultivated rice field, as shown in Figure 4.2.

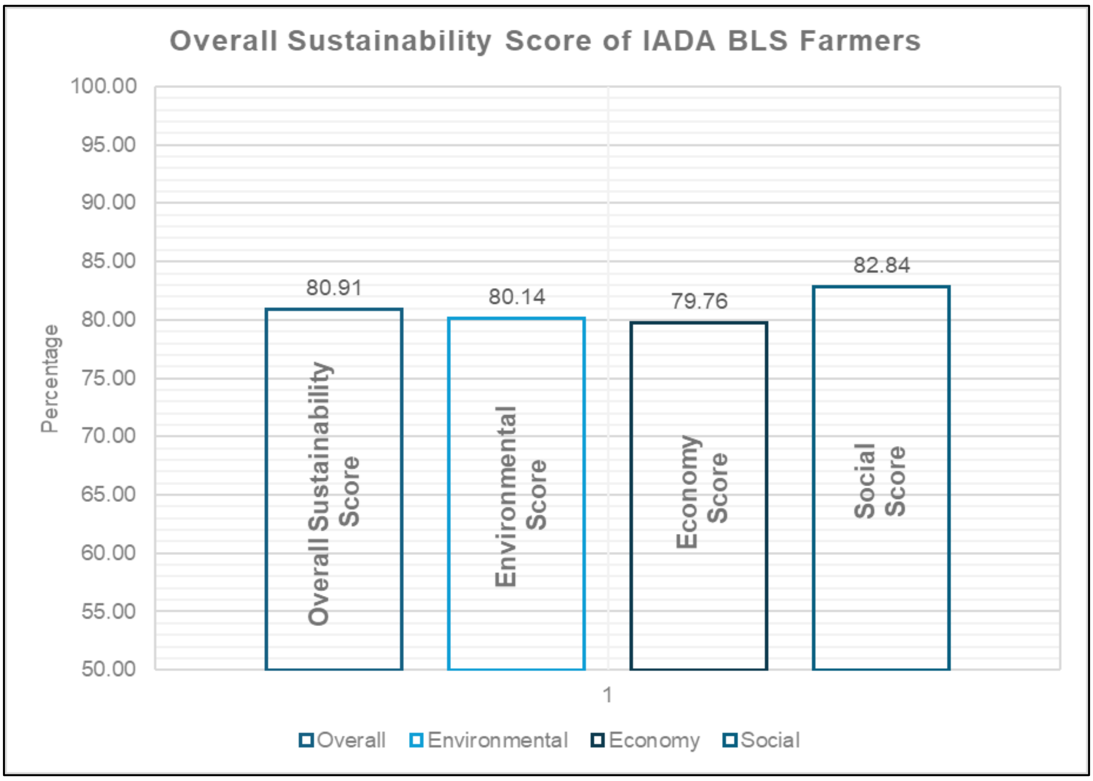


Figure 4.2 IADA BLS Farmer Overall Sustainability Score (Created by Researcher)

Based on the criteria results and the criteria-aggregation score calculation in Table 4.7, seven criteria exceed the 40% threshold. Zero burning practices, Pre-planting, harvesting, and post-harvesting, Species Diversity, Quality of Life, Capacity Development, and Workplace safety, all of which 100% of farmers achieved above 40%, which shows strong performance. However, the criteria are low: only 57.77% are above the 40% threshold, indicating that rice farmers' agricultural practices need improvement. Table 4.11 shows the Rank of the criteria score based on the percentage of rice farmers above and below 40%.

Table 4.11
Rank of The Criteria Score Based on The Percentage of Rice Farmers Over 40% and Below 40%.

Rank	Criteria	>40 %	<40%
1	Zero burning practices	100%	0%
1	Pre-planting	100%	0%
1	Harvesting and post-harvesting	100%	0%
1	Species Diversity	100%	0%
1	Quality of Life	100%	0%
1	Capacity Development	100%	0%
1	Workplace safety	100%	0%
2	Water resources	97.77%	2.22%
2	Value Creation	97.77%	2.22%
2	Right to use land	97.77%	2.22%
2	Employment condition	97.77%	2.22%
3	Planting material	95.55%	4.44%
3	Stability of Production	95.55%	4.44%
4	Fertilizer Input	93.33%	6.66%
4	Traceability	93.33%	6.66%
5	Efficiency of energy use	91.00%	8.88%
6	Stability of Supply	88.88%	11.88%
7	Waste management and disposal	84.44%	15.55%
7	Liquidity	84.44%	15.55%
8	Pest Input	57.77%	42.22%

The normalisation score reveals the top 10 high-performance sub-indicators, with 40% or more of the threshold value, for all farmers. The sub-indicator was 1) Weed management 2) Drying and stalk visualisation, 3) Land preparation schedule, empty field, and field supervision, 4) local taxes and Zakat, 5) Tools and equipment, 6) Employment contracts, 7) Receive seed from certified seed provider, 8) Utilization of Government and NGO Support Programs, 9) Disease management 10) Irrigation and Drainage System Functionality, Maintenance field bund (batas), Farm Road and The five worst performance sub-indicators (red colour highlight) below 40% that need improvement are 1) Diversification of income, 2) Record of Contracts and Agreements, 3) Organic pesticide (Natural ingredients), 4) Amount of biological fertilizer consumption, and 5) Amount of chemical pesticide consumption. The percentage of rice farmers in the high- and worst-performing groups, based on the sub-indicator, is shown in Table 4.12.

Table 4.12

Rank of Best to Worst Performance of The Sub-Indicator on Percentage of Farmers.

Rank	Sub-indicator symbol	Unacceptable 20-0 %	limited 20-40 %	Moderate 40-60 %	Good 60-80 %	Best 80-100 %
1	EVC10I16Sb1	0.00	0.00	0.00	2.22	97.78
1	EVC4I6Sb1	0.00	0.00	0.00	2.22	97.78
3	EVC3I5Sb1	0.00	0.00	0.00	4.44	95.56
4	ECC15I22Sb1	0.00	2.22	0.00	0.00	97.78
4	ESC20I27Sb2	0.00	0.00	2.22	2.22	95.56
4	ESC19I26Sb1	0.00	2.22	0.00	0.00	97.78
7	EVC7I13Sb1	0.00	0.00	4.44	0.00	95.56
8	ECC12I18Sb6	0.00	0.00	2.22	6.67	91.11
9	EVC10I16Sb3	0.00	0.00	4.44	2.22	93.33
9	EVC3I4Sb1	0.00	2.22	0.00	4.44	93.33
11	ESC20I27Sb6	0.00	4.44	0.00	0.00	95.56
11	EVC2I2Sb1	0.00	4.44	0.00	0.00	95.56
13	EVC10I16Sb2	0.00	4.44	0.00	2.22	93.33
13	ESC18I25Sb1	0.00	2.22	0.00	8.89	88.89
13	EVC10I16Sb5	0.00	0.00	6.67	2.22	91.11
13	EVC1I1Sb2	0.00	0.00	0.00	15.56	84.44
17	EVC4I8Sb1	0.00	0.00	6.67	4.44	88.89
18	EVC2I2Sb2	0.00	0.00	2.22	15.56	82.22
19	ESC16I23Sb1	0.00	0.00	0.00	22.22	77.78
20	ESC20I27Sb4	0.00	0.00	2.22	20.00	77.78
21	EVC4I7Sb1	0.00	2.22	2.22	20.00	75.56
22	EVC5I10Sb1	0.00	6.67	0.00	11.11	82.22
23	ESC20I27Sb3	0.00	0.00	6.67	24.44	68.89
24	EVC10I16Sb4	0.00	0.00	4.44	31.11	64.44
25	ECC13I19Sb1	0.00	4.44	2.22	26.67	66.67
26	ECC11I17Sb1	2.22	2.22	13.33	6.67	75.56
27	ESC17I24Sb1	0.00	0.00	0.00	53.33	46.67
27	ECC12I18Sb5	0.00	6.67	2.22	28.89	62.22
29	ESC20I27Sb7	0.00	0.00	11.11	35.56	53.33
30	ECC12I18Sb4	0.00	11.11	2.22	22.22	64.44
31	EVC5I9Sb1	13.33	0.00	0.00	8.89	77.78
31	EVC1I1Sb3	0.00	4.44	4.44	40.00	51.11
33	EVC6I12Sb1	0.00	2.22	17.78	22.22	57.78
34	ESC20I27Sb5	0.00	4.44	6.67	40.00	48.89
35	ECC12I18Sb3	0.00	8.89	4.44	31.11	55.56
36	ESC20I27Sb1	0.00	2.22	13.33	44.44	40.00
37	ECC13I19Sb3	0.00	11.11	13.33	22.22	53.33
37	ECC11I17Sb2	4.44	4.44	2.22	2.22	77.78
39	EVC9I15Sb1	11.11	6.67	4.44	8.89	68.89
40	ECC14I20Sb1	0.00	6.67	6.67	51.11	35.56
41	ECC12I18Sb1	0.00	6.67	11.11	44.44	37.78
42	EVC10I16Sb6	0.00	4.44	2.22	71.11	22.22
43	EVC3I3Sb1	0.00	15.56	20.00	20.00	44.44
44	EVC1I1Sb4	0.00	13.33	8.89	51.11	26.67

45	ECC14I21Sb2	0.00	13.33	15.56	42.22	28.89
46	EVC6I11Sb1	0.00	24.44	6.67	28.89	40.00
47	EVC1I1Sb1	0.00	15.56	22.22	44.44	17.78
48	EVC5I9Sb2	4.44	4.44	2.22	0.00	62.22
49	ECC13I19Sb2	0.00	46.67	11.11	15.56	26.67
50	ECC12I18Sb2	0.00	37.78	24.44	28.89	8.89
51	EVC8I14Sb2	48.89	0.00	0.00	0.00	51.11
52	EVC9I15Sb2	55.56	0.00	0.00	0.00	44.44
53	EVC8I14Sb1	71.11	2.22	4.44	0.00	13.33

4.5 Chapter Summary

This chapter presents the main research results on the Malaysian Sustainable Rice Index (MySRI) and on the sustainability of rice farming practices among rice farmers. Three objectives have been successfully achieved through the assessment of criteria, and indicators and sub-indicators have been developed. In the first objective, sustainability criteria and frameworks from international and local sources yielded 27 proposed criteria with indicators across three sustainability dimensions: social, economic, and environmental. The results of the study show that each relevant criterion is suitable for the proposed criterion, which is adapted from MyGAP, MSPO, SRP, SAFA, and RSPO.

Through an interview with an expert, the proposed criteria were refined and reduced to 20 finalised criteria and 58 sub-indicators, which became the basis for the MySRI assessment. Improvements were achieved through integration, elimination, and alignment, which are not easily measurable. These criteria include three dimensions, 12 elements, and indicators that become the basis for assessment. As for the assessment using the developed MySRI, 45 farmers under IADA BLS reported a moderate-to-good level of sustainability, with scores of 60% to 90%. In comparison, four farmers scored over 90%, and two with scores below 55% indicated a need to improve their sustainable practices. Thus, the MySRI development was successful in producing a comprehensive, context-specific assessment tool that holistically assesses identified weaknesses in sustainable practices.

CHAPTER 5
DISCUSSION

5.1 Introduction

In this chapter, we present a discussion based on the results of Chapter 4, which state that the theoretical sustainability criteria or framework were proposed and finalised, and that the Malaysian Sustainable Rice Index (MySRI) was developed to assess rice farmers' sustainability practices in Malaysia. This discussion focuses on the results of studies with each objective, the current sustainability framework, the sustainability theory, and the rice cultivation system. This chapter is organised according to the objectives: 1) identify and analyse sustainability criteria and indicator for rice farmers based on environmental, economic, and social dimensions by referring to the current sustainability framework, cultivation practices and guidelines, 2) validation of identified sustainability criteria based on contextual and practical relevant for rice farmers by referring to the opinion of experts in sustainability and rice cultivation and 3) sustainability performance of rice farmer cultivation practices assessment in Integrated Agricultural Development Area (IADA) Northwest Selangor and develop a sustainability index using mathematical algorithm.

5.2 Proposed Sustainability Criteria and Indicators.

Sustainability assessment of rice, focusing on farmers, ensures food security, farmers' economic resilience, and balanced environmental care. Economic assessment of sustainable rice farming practices can identify practices that increase revenue and reduce costs (Er et al., 2021). Sustainability assessment also employs qualitative methods that provide fundamental insights into rice farmers' experiences (Firouzjaie et al., 2007; Rahman et al., 2024). In addition, frameworks such as the Sustainable Rice Platform, which have their own assessment methods, have been found to contribute to increased yields, more efficient water use, and the maintenance of food security during natural disasters (Doni et al., 2016; Limi et al., 2022). Moreover, using various sustainability assessment methods enhances overall resilience across economic, environmental, and social dimensions (Harun et al., 2021). Therefore, existing sustainability criteria or frameworks provide a fundamental pillar, although they are context-specific; different crop types, practices, rules, and regulations may be relevant to Malaysian rice cultivation.

In the selected sustainability criteria or frameworks, such as MSPO, which focuses on oil palm plantations in Malaysia, traceability, good governance, no deforestation, and the welfare of workers and communities are emphasised. Whereas MyGAP, which focuses on general food crops, emphasises good agricultural practices towards the environment and society. SRP was very suitable for rice cultivation, which focuses on rice farmers, farmer groups, and authorities that are not yet adapted in Malaysia. On the other hand, the SAFA framework, which has general criteria applicable to all countries, focuses on livestock, crop production, and fisheries. The same applies to RSPO, which is aligned with MSPO and focuses on oil palm. In these criteria frameworks, the same universal criteria as presented in Table 4.1 are included, namely soil quality, replanting, energy use, waste, etc. These criteria are present in each framework derived from previously developed and current international sustainability frameworks, such as the UN Agenda, UNEP, DPSIR, UNCSD, and SDGs (Georgeson et al., 2017; Pedersen, 2018; Singh et al., 2012; Spangenberg et al., 2002). However, some criteria in these frameworks, such as zero-burning practices, do not apply to paddy crops in Malaysia, as farmers are not allowed to burn rice residue. However, one criterion, such as zero-burning practices, cannot be directly applied to paddy crops in Malaysia because it is not aligned with the Malaysia Environmental Quality Act 1974 [127 ACT]. Therefore, there is a need to reaffirm these criteria for paddy crops in Malaysia.

The proposed criteria must align with rice cultivation in Malaysia. In this study focusing on rice farmers, the IADA BLS was included. Therefore, 27 criteria have been reviewed, which must be aligned to account for different environmental conditions, rules, and socio-economic factors (De Olde et al., 2017; Herman, 2024; Talukder et al., 2018). One of the criteria in the SAFA framework for the environment dimension that does not align is Genetic diversity, which requires conserving and improving wild species or varieties. This criterion is not suitable because rice farmers have limited resources and can only achieve it through a large enterprise or a government organisation. It also does not align with rice farmers' cultivation practices as outlined in the Malaysian Rice Check Guideline. On the contrary, these criteria are influenced by participatory approaches. When proposing criteria, it is necessary to obtain the opinions of industry or sector stakeholders aligned with the focus criteria. In this study, experts in sustainability and rice farmers were selected to obtain their opinions. This expert knowledge ensures that the proposed indicators or criteria are relevant and accepted locally (De Olde et al., 2017; Kurka & Blackwood, 2013).

In addition, it is influenced by limitations in social sustainability. The criteria for social sustainability are underdeveloped and need contextual adaptation (Brennan et al., 2020; Herrera et al, 2022). In this study, the MSPO Social Impact Assessment criteria are necessary to ensure that an organisation minimises negative social impacts, but they are not appropriate for rice farmers with limited capital. While the quality-of-life criteria from SAFA are appropriate for rice farmers, their intent is broad, and they can focus on rice farmers' capabilities, as proposed in the right-to-quality-of-life measurement. Lastly, the rules and policies of the county context (Bujdei, 2024; Movahhed et al, 2025). According to the criteria for zero-burning practices in MSPO, RSPO, and SRP, crop residue may be burned only in cases of severe disease or pest infestation. If these criteria are finalised for rice farmers in IADA BLS, it will provoke controversy, as open burning of rice residue is permitted under the Environmental Quality Act 1974 [127 ACT].

According to the review results, the proposed criteria include both strong and weak factors in terms of relevance and practicality for farmers' rice cultivation. The 27 proposed criteria showed strong applicability, as shown in Table 5.1. Therefore, these criteria can be measured by rice farmers in IADA BLS, while appropriately used in the sustainability assessment.

Table 5.1
Summary of Strong Applicability Criteria.

	Criteria	**Contextual alignment**	**Issue**
1	Zero burning practices	Align with Rice Check Guideline	Lack of environmental behaviour and air pollution (Ali et al., 2021; Sharaai et al., 2022)
2	Water resources		High-level water withdrawal (Hanafiah et al., 2019; Sariam & Anuar, 2010).
3	Soil quality		Heavy metal contamination (Sibuar et al., 2022).
4	Replanting		Non-compliance with the Rice Check guideline (Mohamed et al, 2016; Zainol & Abu, 2023).
5	Harvesting and post-harvesting		
6	Efficiency of	Fossil fuel consumption	Highly dependent on fossil

	energy use and use of renewable energy	in rice cultivation (Nawi et al., 2024)	fuel (Muazu et al., 2015)
7	Waste management and disposal	Align with Rice Check Guideline	Low awareness of disposal of input material (Sariam & Anuar, 2010)
8	Planting material	Align with the Rice Check Guideline, and as stated in the MyGAP framework	No issue found
9	Pest input control	Align with Rice Check Guideline	Excessive fertiliser and pesticide use (Fuad et al., 2012; Mohamed et al, 2016)
10	Fertilizer input		
11	Ecosystem diversity		
12	Species diversity		
13	Profitability	SRP, SAFA, MSPO, and RSPO stated that organisations or farmers need to demonstrate their profitability.	Lack of financial support, understanding, and rising cultivation cost (Makhtar et al, 2022; Rahim et al, 2022)
14	Traceability	Align with Rice Check Guideline	Non available
15	Stability of production	Not stated in the Rice Check Guideline, it affects rice production in Malaysia and other crops.	Shortage of rice seed (Ahmad, 2019)
16	Liquidity	Liquidity, as defined in the SAFA framework, strongly influences rice production in Malaysia.	Unaware specialised accounting record (Mustafa et al., 2016)
18	Risk management	Not stated in the rice check guideline. However, the SAFA, RSPO and MSPO frameworks are stated to be contextually aligned with rice cultivation, even though the criteria were general.	No issue found
19	Value creation	Not stated in the rice check guideline. However, the SAFA and MSPO frameworks are stated to be contextually aligned with rice cultivation, even though the criteria were general.	
20	Local procurement	Not stated in the rice check guideline.	

		However, the SAFA frameworks are stated to be contextually aligned with rice cultivation.	
21	Quality of life	Not stated in the rice check guideline. However, the SAFA and SRP frameworks are stated to be contextually aligned with rice cultivation.	Low expectations on quality of life in rural areas by the younger generation (Terano & Mohamed, 2013)
22	Capacity development	The rice farmers were under the supervision of IADA BLS, which provided them with training and knowledge. This criterion is also stated in the SRP, MyGAP, and the SAFA framework.	No issue found
23	Fair access to means of production		
24	Right to use land	Not stated in the rice check guideline. SAFA, MSPO, and RSPO stated the need for land ownership rights to cultivate or operate.	
25	Employment condition	Not stated in the rice check guideline. However, as stated in the Malaysian Employment Act 1955, the indicator means this criterion is relevant.	
26	Living condition	Not stated in the rice check guideline. MSPO and RSPO stated the criteria due to the underdeveloped labour rights.	
27	Workplace safety	Not stated in the rice check guideline. However, it is stated in the Occupational Safety and Health Act 1994, for the indicator means this criterion is relevant.	Ali et al., 2021

In the review, six criteria were identified as weak for assessing rice farmers, but they are important. The criterion was ecosystem diversity; although it is not stated in the rice check guideline, it aimed to encourage farmers to practice good environmental management around rice fields and to promote crop diversity, as stated in the SAFA framework. Whereas for the criteria of supply stability, risk management, value creation, and local procurement, it is important because it affects rice farmers' production. However, this criterion requires rice farmers to include operational costs for documentation and consultation. For the value-creation criterion, the focus is on farmers' contributions to employment and local taxes, which do not significantly affect rice farmers' output. Therefore, this weak criterion is theoretically important but broad, and it lacks operational measures for rice farmers under IADA BLS. The review of the sustainability framework revealed a strong foundation in the 3-pillar sustainability concept. However, lacked context-specific criteria for Malaysian rice farmers, and none aligned entirely with the IADA BLS irrigation scheme and the Malaysian Rice Check Guideline. Therefore, this limitation indicated the need to develop a theoretical framework or criteria specific to paddy cultivation for farmers in Malaysia to serve as the basis for assessing the sustainability index.

The proposed sustainability criteria were anchored in the three pillars of sustainability and integrated the environmental, economic, and social dimensions as interconnected components of sustainable rice cultivation. These criteria provide a foundation for MySRI and reflect that sustainability cannot be measured in a single performance domain. In rice cultivation, these dimensions are always interrelated and must be assessed to obtain a picture of sustainability performance. Assessment in agriculture requires three dimensions because low levels in one dimension cannot be compensated for by high levels in another (Sulewski et al., 2018). The environmental dimension ensures that rice crops reduce environmental damage by minimising excessive agrochemical use, water use, and poor residue management. This dimension reminds rice farmers to preserve the environment and to practice sustainable agriculture. However, environmental sustainability cannot be achieved today without economic resilience. Rice farmers who lack financial resources and risk management practices cannot fully commit to the objective environmental dimension.

In terms of the social dimension, rice cultivation affects the lives of rice farmers, their workers, and surrounding communities. This dimension ensures that developed agriculture does not neglect the welfare of its workers and the surrounding community.

The social dimension is important because quality of life is a key component for understanding farmers' needs and providing appropriate support programs (Wojewódzka et al., 2019). In this study, farmers in the granary area supervised by IADA BLS significantly influence sustainability performance. Indicate applying social indicators to focus on governance and livelihood concerns instead of production indicators. Therefore, integrating the three pillars of the sustainability concept into the MySRI assessment provides conceptual coherence for assessing sustainable agricultural practices at the farm level. This ensures that rice cultivation in Malaysia is assessed in a balanced manner, considering environmental responsibility, economic feasibility, and social accountability as components of sustainable agricultural development. Existing sustainability frameworks such as SAFA, SRP, MSPO, RSPO, and MyGAP are important for guiding sustainable agricultural development, but they were designed to address different contexts, including commodities, governance, and practices. Therefore, direct adaptation of the principles, criteria, and indicators of these frameworks without alignment with Malaysian contextual practices and policies will reduce their suitability for assessing sustainability practices among Malaysian rice farmers.

Previous studies have stated that sustainability criteria and indicators must be context-specific and aligned with local agricultural practices, environmental conditions, and stakeholder contexts because the concept of sustainability is multidimensional and influenced by local operational realities (Hayati et al., 2010; Riley, 2001; Valizadeh & Hayati, 2021). In agricultural sustainability assessment, criteria and indicators cannot be fully applied to a particular farming system because they are influenced by local geographical and environmental conditions such as weather, soil type, and water availability (Hakimi & Hamdoun, 2023; Ul Haq & Boz, 2018). In addition, this matter is influenced by data availability, where not all agricultural areas have the necessary data to measure the indicator (Deng & Mohamad, 2026; Folberth et al., 2025). In fact, criteria and indicators must also be aligned with the priorities of local stakeholders such as farmers, policymakers and researchers to ensure relevance and usability (Folberth et al., 2025; Santiago-Brown et al., 2015), and there are trade-offs where global criteria and indicators often prioritise comparability over specificity that may not align with local sustainability objectives (Deng & Mohamad, 2026). These matters are important in the context of this research because rice farming practices in Malaysia are not all aligned with this sustainability framework, with differing regulations and laws, crop management, input management, irrigation management, farmer well-being, safety and health, and financial priorities. One example is that the zero-burning practices set by MSPO and RSPO do not allow open burning, but in rice cultivation in Malaysia, it is still allowed under the laws set by the Department of Environment Malaysia. Therefore, the proposed criteria and indicators underscore the need for a context-specific sustainability framework for Malaysian rice farming that is operationally measurable, contextually relevant, and strongly aligned with international and local sustainability frameworks. The proposed sustainability criteria established in the first objective strengthen the development of the Malaysian Sustainable Rice Index (MySRI) by integrating international and local sustainability criteria, specifically adapted to Malaysian rice farmers' cultivation practices.

5.3 Validation of Sustainability Criteria and Indicators

In the refinement process, the 27 criteria proposed in objective 1 are required because not all of them remain relevant to Malaysian rice farmers, even though they have been aligned with the sustainability framework, practices, and local cultivation guidelines. The review shows that the criteria are not directly usable for the assessment. There are criteria such as quality of life and risk management that are broad and lack measurable indicators. The review criteria were theoretically aligned, but the unit of measurement was rice farmers. The information required from the rice farmers must be available for measurement in the assessment for objective 3. In addition, criteria beyond rice farmers' control make it challenging to obtain the data. Thus, expert refinement was needed to evaluate the relevance and practicality of the criteria.

Every criterion proposed to the expert has increased credibility and applicability and reduced the researcher's biases. The index was developed without expert judgment on its theoretical framework, rendering it unusable. Thus, the expert contributed to transparency (De Olde et al., 2017; Reid & Rout, 2020). Emphasising uncertainty, explicit value, and transparency on these criteria adds credibility and trust. The opposite is considering spatial and temporal variability (Ibrahim et al., 2025; Vazhnik et al., 2018). This expert considers the spatial and temporal diversity in the rice crop system with data, frameworks, and local indicator sets. In addition, customisation of international criteria to the local context (Astari et al., 2022; Renthlei & George, 2025). The proposed criteria or framework invite experts to refine them to ensure a relevant and actionable assessment of local criteria. In fact, experts also identify gaps in criteria such as methodological inconsistencies, thereby enabling improvements and reducing biases (Cinelli et al., 2014; Garcia et al., 2025).

Based on the proposed 27 criteria, 20 have been finalised as the basis for evaluating rice farmers. Seven criteria have been eliminated, including Soil quality, Ecosystem diversity, Profitability, Risk Management, Local Procurement, Fair Access to Means of Production, and Living conditions. The soil quality criteria were removed because most experts disagreed on maintaining them. Moreover, Expert 14 stated, "difficulty for rice farmers to assess heavy metals due to a lack of equipment." Expert 11 stated that farmers will be burdened with this criterion. As for the ecosystem diversity criteria, 7 of 12 experts disagreed that they should be maintained due to the complexity of measurement. One of the experts stated, "to encourage farmers first to create ecosystem services" (Expert 16). Expert 15 stated, "farmers not being able to achieve these criteria". Likewise, with local procurement criteria, fair access to means of production and living conditions. These criteria can be met by larger enterprises or government organisations with significant resources, such as capital and knowledge. The 20 criteria and indicators are maintained because they have high impact, are quantifiable, modifiable, data-available, align with national rules and regulations, and have more than 50% expert agreement relevant to each criterion, as presented in Table 5.2.

Table 5.2
Summary of Finalised Criteria

Dimension	Element	Criteria	Indicator
Environmental	Air	Zero burning practices	Rice Stubble and Rice Straw
	Water	Water resources	Water management
	Land	Pre-planting	Land Suitability
			Surveillance of Rice Field
			Land preparation
		Harvesting and post-harvesting	Timing of harvest
			Harvesting equipment
			Post-harvest handling
	Material And Energy	Efficiency of energy use	Non-renewable energy consumption
			Mechanism of action for reducing non-renewable energy consumption
		Waste management and disposal	Waste management standard operating procedure
			Farm operational disposal
		Planting material	Pure quality seed
		Pest Input	Chemical pesticide

			Organic pesticide
		Fertilizer Input	Chemical fertilizer
			Organic fertilizer
	Biodiversity	Species Diversity	Integrated Pest Management (IPM)
Economic	Transparency	Traceability	Record keeping
	Vulnerability	Stability of Production	Guarantee of production levels
		Stability of Supply	Procurement Channels/ Input Supplies
		Liquidity	Net Cash Flow
			Safety Nets
	Local economy	Value Creation	Fiscal Commitment
Social	Decent livelihoods of farmer	Quality of Life	Right to Quality of Life
		Capacity Development	Capacity Development
		Right to use land	Proof of ownership
	Labour right	Employment condition	Employment relations
	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

The refinement reduced the number of criteria to 20 and improved their descriptions, structures, and intents. Some of the 27 proposed criteria were removed or modified. The zero burning practices criteria initially did not allow farmers to burn their rice residue; it was changed to “allowed to burn rice straw and stubble after harvesting. They also discourage burning by using decomposed materials (microbes), allowing for ploughing and use as a byproduct. While the water resource criteria focus on water management and drainage, water management has been maintained in accordance with the Malaysian Rice Check guideline. Drainage includes timely crop establishment in accordance with the IADA BLS timetable. Moreover, in the replanting criteria, the term "replanting" has been changed because it is not suitable for paddy crops before planting. Its indicators, namely levelling, field boundary, and nutrient management, have been changed to land suitability, surveillance of paddy field, and land preparation, which are adapted based on the Rice Check Guideline. Levelling is not suitable for paddy farmers due to the cost of equipment, and most farmers still do it traditionally. The field boundary has been merged with the paddy field surveillance indicator. Criteria for harvesting and post-harvesting have been maintained, with a brief description of the harvest-time indicator for "moisture content used and physical inspection of rice”.

The energy use criteria have been removed and replaced with non-renewable energy consumption and mechanism action. Similarly, regarding waste management and disposal, the management plan was revised into a standard operating procedure for waste management, with waste reuse integrated into farm operational disposal. Next, the material planting criteria are maintained, with an improvement to the description stating that seed cannot be used from previously harvested seed or bought from a friend. Instead, buy from certified seed providers. Fertiliser and pesticide input criteria have been maintained. Regarding the species diversity criterion, the invasive species indicator was removed due to its immeasurability, and only integrated pest management (IPM) was retained, with slight improvements to the descriptions of each IPM component, including insects, weeds, diseases, molluscs, rodents, and birds. On the other hand, the traceability criteria and indicators have been maintained. The criteria for production stability are maintained by outlining five plans for rice farmers to mitigate the effects of environmental and economic shocks.

The criteria for supply stability are maintained by adding action plans to evaluate rice farmers. The liquidity criteria are maintained, and the value-creation criteria for the regional workforce indicator are removed only if fiscal commitment is maintained. On the contrary, the quality-of-life criterion was improved in the description, even though this criterion was broadened by focusing on the farmer's personal needs. As for the capacity development criteria, the rights to land use, employment, and workplace safety have been maintained. Overall, the refinement produced measurable, context-specific criteria. By ensuring quick data collection and light scoring, the revised criteria encourage completion within a manageable timeframe without sacrificing depth. Therefore, the foundation criteria were academically sound and established for rice farmers in Malaysia.

Expert validation criteria enhanced contextual relevance and measurement clarity. The content validity procedure strengthens the credibility of selected sub-indicators and ensures that this variable reflects the actual practice of rice cultivation in Malaysia. A comparison of the criteria and indicators with those of the previous index in Malaysia shows that the MySRI index expanded across several areas, as shown in Table 5.3. Comparison showing the criteria and indicators developed for MySRI, focusing on contributions to developing and strengthening selection methods and on contextual relevance in sustainability assessment in the Malaysian rice cultivation system.

Table 5.3
Criteria and Indicator Development Comparison.

Feature	POMSI	SUFIA	ASI	SFMI	MySRI
Dimension	Environment, Economic, Social	Environment, Economic, Social	Environment, Economic, Social	Environment	Environment, Economic, Social
Context	Palm oil	Vegetables	Rice	Rice	Rice
Methodology	Literature review and expert judgment	Literature review	Literature review	Literature review	Literature review, expert judgment, Content validity
Assessment level	Farm level/ Palm oil mill	Farm level	Farm level	Farm level	Farm level
Framework-based and indicator	Local and international Palm Oil Sustainability Framework and past literature	Past literature	Past literature	Past literature	Local and international agriculture, rice, and palm oil frameworks and past literature

Sustainability criteria and indicators validated in phase 2 show that sustainability assessment in the context of Malaysian rice cultivation requires a multidimensional framework to capture the complex interactions among environmental conservation, economic resilience, and social well-being. The inclusion of 20 criteria with their indicators indicates that sustainable rice cultivation in Malaysia must consider air, water, land, materials and energy, biodiversity, transparency, vulnerability, local economy, decent livelihoods of farmers, labour rights, and human safety & health elements. The finalised criteria align with past sustainability studies, which state that sustainability is multidimensional and requires integration of the environmental, economic, and social dimensions (Sulewski et al., 2018; Wei et al., 2009), thereby improving the understanding of a system's overall sustainability. In addition, the finalised criteria show that Malaysian rice cultivation is context-dependent, that is, influenced by local farming systems, irrigation management, institutional support by the government, and farmer practices based on the Malaysian Rice Check Guideline. Several criteria and indicators reflected sustainability issues in rice farming in Malaysia, such as input management, financial accounting, standard operating procedures, and safety and health (Ali et al., 2021; Harun et al., 2022; Mohamed et al., 2016; Saiful Nathan & Mohd Rosli, 2016). Therefore, general criteria and indicators in agriculture or the international context do not fully reflect the farming context in Malaysia without contextual adaptation. Same concerns reported in past studies: sustainability indicators should be context-specific and measurable within a given assessment context to ensure that sustainability evaluation reflects the condition and the management system (Gennari & Navarro, 2019; Zhen & Routray, 2003). In addition, the finalised criteria have improved the practical and operational suitability of sustainability assessment at the farm level by integrating indicators for assessed rice farmers in the Malaysian context. This is important because the limitation identified in previous indices was a lack of integration of indicators that aligned with sustainability concepts and local practices. Therefore, the finalised criteria further strengthen the basis of MySRI, which is parallel to the concept of sustainability and is measurable and contextually relevant among rice farmers in Malaysia. In essence, these finalised criteria enhance applicability and provide a holistic approach for rice cultivation in Malaysia.

5.4 MySRI Sustainability Assessment

The results of the index assessment indicate that sustainability practices were still present among Malaysian rice farmers. The sustainability score distribution indicates a transitional landscape in which the farmer neither fully meets sustainability standards nor is considered entirely unsustainable, suggesting that agricultural sustainability practices are still developing. The majority of farmers achieve over 60% sustainability performance, while only two farmers fall below 60% but are still considered sustainable. Previous studies on rice farmers in Malaysia reported scores ranging from 30.38% to 76.04% in 2015 (Ajidasile, 2015). Two past studies indicate that the sustainability performance of 80% and 50% of rice farmers in the selected location was unsustainable (Mohamed et al., 2016; Terano et al., 2015). There is also an international sustainability assessment that uses the SRP framework as a basis, which indicates 53% to 81% of farmers' performance, the same result as this study (Mungkung et al., 2022). Based on this past study, there is an increasing trend in sustainability status in Malaysian rice cultivation, even in line with international standards. This trend also shows that rice farmers in Malaysia have increasingly adopted sustainable agricultural practices and that agricultural agencies' efforts to promote sustainable agriculture have been successful.

5.4.1 Best Sub-Indicator

Based on the index assessment results, the top 5 sub-indicators received higher performance in terms of the percentage of rice farmers. The analysis showed that the sub-indicator weed management performed better due to good management practices in weed control, using manual and chemical weeding. This finding is consistent with Dilipkumar et al. (2021), who found that most farmers were able to recognise weedy rice and adapt weed control strategies, such as water seedling, transplanting, and manual weeding, indicating good weed identification knowledge. In addition, Kamaruddin and Abd. Rashid (2025) found that weed management under the IPM component achieved high sustainability performance in IADA BLS, with 74.2% adopting sustainable weed management practices and following the recommended procedures. They also found that other farmers in different regions received an average value, indicate there still farmer failed to follow weed management procedures. This suggests that continued extension support, training, and monitoring are necessary to ensure implementation of weed management practices. The finding highlights that weed management is a key sub-indicator in the sustainability index and demonstrates its importance in environmental conservation practices. Furthermore, high performance on the sub-indicators of drying and visualisation of stalks indicates that rice farmers in IADA BLS generally adopted appropriate drying and water management practices. The finding is supported by Sriphirom et al. (2021), who reported that effective drying management using Alternate Wetting and Drying (AWD) reduces water use, lowers greenhouse gas emissions, improves water productivity, and maintains rice yield. Thus, the finding shows proper drying practices contribute to production efficiency and also environmental sustainability. Moreover, the finding is consistent with Xangsayasane et al. (2019), who reported that proper drying management contributes to better grain quality, higher head rice recovery, and improved economic returns.

Other than that, high stalk visualisation performance demonstrated good farmers' ability to visually assess crop maturity before harvesting. This aligns with Haw et al. (2014): the maturity of rice can be determined by changes in floret colour and rice variety. These high-performance scores for drying and stalk visualisation indicate that rice farmers in IADA BLS possess good knowledge and skills in managing harvest operations. These findings suggest that farmers in IADA BLS successfully adopted practices that support economic and environmental sustainability, highlighting this sub-indicator as important for sustainable rice cultivation.

Besides that, the sub-indicators Land preparation schedule, empty field, and field supervision also showed higher performance. The finding generally aligned with Kamaruddin and Abd. Rashid (2025) reported that farmers adopting recommended agricultural practices achieved higher sustainability performance. This finding aligned with Mairghany et al. (2022), who stated that proper scheduling of flooding, irrigation, and land preparation is important for improving planting quality, reducing planting losses, and enhancing rice production efficiency. The high performance of these sub-indicators indicates that rice farmers implement good planting planning and management practices. This indicates that the farmer was capable of conducting timely field operations and monitoring field conditions effectively. Thus, proper scheduling and supervision can improve planting efficiency and support sustainability practices in rice cultivation. Further, on the sub-indicator, local taxes and Zakat indicate higher performance. This finding aligns with Ab Rahman et al (2023), who highlighted that agricultural zakat promotes socioeconomic justice and supports community welfare. Agricultural zakat also important obligation for eligible farmers and serves as a mechanism for wealth redistribution and social welfare (Hamat, 2014). These high-performance scores suggest farmer generally comply with their financial and religious responsibilities, reflecting social responsibility and community welfare. Thus, the farmer focuses not only on production but also on social sustainability by supporting welfare distribution and economic development in rural communities.

In addition, the sub-indicator employment contract shows higher performance. This finding is generally aligned with Fauzi et al. (2013), who highlight the importance of maintaining employee-employer relationships, retention, and commitment that contribute to workforce stability and support social sustainability. Further, the findings were aligned with Abdul & Abdulai (2020), rice farmers participating in written and verbal contractual agreements achieved better farm performance than relying on spot market transactions. This reflected good labour practices that enhance communication, accountability, and coordination of farm activities. This shows that effective employment agreements contribute to workforce stability and social sustainability.

5.4.2 Worst Sub-Indicator

While best-performance sub-indicator findings showed major alignment with sustainability practices. There were 5 weak sub-indicators identified among rice farmers, such as weak contracts and agreements with suppliers on input supply. The finding aligned with Tuyen et al. (2022), who identified input provision as a critical contract attribute and several challenges related to input supply arrangements, supply delays, unsuitable inputs, and dissatisfaction with the contractor-controlled input system. Further, the finding aligned with Kumar et al. (2013), who highlighted that weak contract enforcement led to contract breaches and that information asymmetry between parties creates distrust, necessitating contractual arrangements to improve cooperation and reduce transaction risk. This low-performance sub-indicator suggests that rice farmers may face challenges maintaining effective contractual relationships with input suppliers, creating uncertainty in input provision and supplier commitments. Thus, strengthening contractual arrangements and trust between the supplier and the farmer could improve reliability, reduce risk, and enhance transparency.

Moreover, the finding identifies income diversification as a weak performance. The finding aligned with Saiful Nathan & Mohd Rosli (2016), identified 715 of rice farmer households had at least one source of non-farm income, with non-farm income contributing 33% of total household income. Moreover, the finding by Antara et al. (2023) highlighted that average income diversification among rice-farming households was low and that higher-income diversification was likely to achieve food security. As stated, income diversification was an important strategy for resilience, reducing poverty and strengthening food security. The low-income diversification shows that rice farmers are highly dependent on rice cultivation as their main source of income, indicating a lack of economic resilience and flexibility and implying they may be more vulnerable to production and market risks. Thus, promoting income diversification could increase farmer resilience and improve economic sustainability. Furthermore, the findings show low performance on the sub-indicator organic pesticide application. These findings are related to Chang et al. (2024), who reported that adoption of organic pesticide farming remains low despite promotional efforts. Moreover, the findings aligned with Meshram et al. (2026), highlighting low adoption of organic pesticides due to higher costs, certification complexity, yield concerns, and the need for technical and knowledge support. The low performance suggests farmers are still heavily dependent on agrochemical pesticides. This implies that the lack of adoption affects environmental sustainability and the need for stronger extension services and incentives to promote organic pesticide applications.

Furthermore, the sub-indicator for biofertilizer usage also indicates weak performance. The finding is broadly consistent with Nordin et al. (2023), who reported that green fertiliser technology adoption among Malaysian rice farmers remains low despite its potential benefits, due to limited access to information and technical knowledge, lack of awareness, perceived conventional practices as more effective, and the need for extension support. Besides that, the finding also aligned with Relawati et al. (2022), who highlighted that adoption remained limited due to farmers being unconvinced of the economic advantages and unwilling to pay higher prices for the product, even though they were aware of bio-activators and their benefits to soil fertility. The low performance of these sub-indicators suggested that rice farmers were still dependent on inorganic fertiliser application despite awareness of the benefits of biofertilizers. Thus, greater extension support, training, awareness, and incentives for the use of biofertilizers by the government.

In addition, the sub-indicator chemical pesticide consumption was the lowest performer among the sub-indicators. The finding aligned with Mohamed et al. (2016), who reported that farmers frequently used chemical pesticides at higher doses than recommended by the Rice Check Guideline. Moreover, Dilipkumar et al. (2021) study also supported the finding, which states that the Malaysian rice farmers excessively relied on chemical pesticides without consideration of the implications on human health and the environment. The low performance of the chemical pesticide usage sub-indicator is a warning sign for Malaysian agriculture, implying short-term high-yield productivity and long-term environmental degradation. Thus, without intervention to reduce excessive reliance on chemicals, the increase in pest resistance, environmental degradation, and compromised farmer health may continue to have a greater impact.

5.4.2.1 Suggestions for Improvement on The Worst Indicators.

The five worst indicators were identified, which were a) amount of chemical pesticide consumption (EVC8I14Sb1), b) Organic pesticide (Natural ingredients) (EVC8I14Sb2), c) Amount of biological fertiliser consumption (EVC9I15Sb2), d) Diversification of income (ECC12I18Sb2), and e) Record of Contracts and Agreements

(ECC13I19Sb2). The worst indicator was identified for improvement based on recommendations from past studies, as shown in Table 5.4.

Table 5.4
Worst Indicator Improvement

Sub-indicator symbol	Improvement approaches	Author
EVC8I14Sb1	Incorporate natural predators and parasites	Sarwar, 2024
	Application of the system of rice intensification (SRI)	Stoop et al., 2017
	Continues to apply Integrated Pest Management (IPM)	Fahad et al., 2025
	Implementation of Ecological Engineering	Sattler et al., 2021
EVC8I14Sb2	Increased government incentives toward the adoption of biopesticides.	Adnan et al., 2024
	A combination of two biopesticides	Ramli et al., 2018
	Infrastructure improvement and community empowerment	Sujianto et al., 2022
EVC9I15Sb2	Diverse organic nutrient sources	Hazra et al., 2018
	A combination of organic and chemical fertilisers for the rice field	Iqbal et al., 2019
	Combination of different organic manures	Iqbal et al., 2021
ECC12I18Sb2	Adding an education topic to diversify livelihoods and skills	Afodu et al., 2019
	Implemented non-farm wage employment	Awotide et al., 2012
	Implemented an intervention program to enhance skills, credit access and income opportunities	Ho, et al., 2024
ECC13I19Sb2	Established a blockchain-based marketplace for trust and transparent transactions	Kandasamy et al., 2025
	Government intervention to enforce the legal system for contract compliance	Pham et al., 2021

5.4.3 Dimension Discussion

Based on the overall findings of the MySRI assessment across all three dimensions, a score above 80.91% indicates the best sustainability performance. Several past studies support this finding, such as Kamaruddin and Abd. Rashid (2025) reported that 76.4% of rice farmers in IADA BLS had a sustainability performance, indicating that sustainability practices are generally positive and contribute to farmer well-being, which is slightly lower than the current MySRI overall finding. Moreover, strongly aligned with Mungkung et al (2022), who reported scores ranging from 53% to 81% of rice farmers' performance assessed using internationally recognised

Sustainable Rice Platform (SRP) indicators. The finding also partially aligned with Roy et al. (2014), who found that fewer than half of rice farmers were sustainable in terms of economic viability, ecological benefits, and quality of life. The research did not provide overall results indicating that the MySRI score was higher than that of Roy et al. (2016) due to differences in countries and farming environments, faces substantial sustainability challenges, and differences in index aggregation. Furthermore, MySRI findings contradict those of Mohamed et al. (2016), who reported that 80% of rice farmers in their study location were unsustainable, with an average score below 40%. The differences stem from their assessment focusing heavily on compliance with the Rice Check Guideline and from differences in index structure and scoring systems. Moreover, a higher MySRI finding, supported by Yasar et al. (2016), found that the sustainability of rice farming was influenced by technological, economic, social, and institutional factors, and that technological advancement was the most important factor contributing to sustainability. In addition, two studies had significantly lower scores than MySRI, which reported that 44% of farmers only achieved sustainability performance; this is due to a context-specific study being conducted, facing sustainability challenges, and having moderate institutional support, irrigation infrastructure, extension services, and subsidies. Ajidasile (2015) reported a sustainability index of 30.38% to 76.04%, with a mean score of 48%, indicating a lower score than the MySRI.

On the environmental dimensions, a performance score of 80.14% was achieved. The study in Thailand reported overall scores ranging from 53% to 81%, influenced by water management, integrated pest management, and farm management, indicating relative similarity with MySRI findings. Many of the indicators used in the study were environmental in nature (Mungkung et al., 2022). Further, slightly lower alignment with Kamaruddin & Abd. Rashid (2025) reported a 76.4% performance score due to this research, which focused on the Rice Check Guideline indicator. Their weak alignment with Yusuf et al (2020), who reported scores ranging from 48.80% to 56.10% among rice farmers, may reflect the differences in environmental management practices, institutional support, and irrigation infrastructure. A previous study that focused solely on the environmental dimension reported a sustainability performance score of approximately 76.4%. However, the two studies are inconsistent with this study's findings, which showed a sustainability performance score of 40.0% (Ajidasile, 2015; Mohamed et al., 2016). At the same time, the economic dimension scored

79.76%, driven by well-supplied inputs and government financial support. This result aligns with past studies, indicating that the MySRI economic dimension score ranges from 50% to 100% of the assessment, as reported by Mucharam et al. (2020). On the other hand, the social dimension showed a sustainability performance score of 82.84%, driven by high satisfaction among farmers with rice cultivation and the well-implemented agricultural agency's training and knowledge extension program. The MySRI social score indicates that, on average, it exceeds the prior literature on two criteria, with the SRP framework as the baseline (Mangkung et al., 2022), yielding a score of 69%. Moreover, it aligns with a score of 50-100% on the social dimensions score (Mucharam et al., 2020).

The overall MySRI performance score of 80.91%, with the environmental dimension at 80.14%, the economic dimension at 79.76%, and the social dimension at 82.84%, demonstrated that Malaysian rice farmers generally practice sustainability at a high level. Previous research suggests that sustainable cultivation practices are increasingly being applied in Malaysian rice cultivation. The higher score compared with previous research may reflect improvements in farm management, adoption of farming technology, strong institutional support, frequent extension services, and high awareness among rice farmers. In addition, the findings demonstrate MySRI capable provided measurable sustainability variables and context-specific assessment by integrating environmental, economic, and social dimensions into a single sustainability assessment tool. In essence, MySRI provided practical value and served as a decision-making support tool for continuous sustainability monitoring, benchmarking, comparison, identification of weak areas for improvement, and evidence-based policy improvement and long-term sustainability planning in the Malaysian rice cultivation context.

5.5 MySRI Development

The development of MySRI directly supports the main objective by introducing a new sustainability index to assess Malaysian rice farmers across environmental, economic, and social dimensions. The development demonstrates that sustainability issues in Malaysian rice cultivation are multi-dimensional, interrelated and influenced by local practices. Therefore, the development of MySRI is important to ensure that sustainability assessments in the context of Malaysian rice cultivation are comprehensive, measurable and contextually relevant through the sustainability assessment approach expanded by previous developers.

In terms of the environmental dimension, MySRI addresses the sustainability problem related to rice cultivation among rice farmers. Environmental criteria integrated into MySRI support research objectives by enabling systematic measurement of environmental agricultural practices at the farm level. Therefore, the integration of environmental criteria and their indicators improve the sustainability practices of these rice farmers by increasing awareness of environmental sustainability in agricultural practices. Additionally, it guides farmers in managing farms and policymakers in balancing economic resilience, environmental impact, and ecological and social well-being (Mangkung et al., 2022). Through the MySRI measurable environment dimension, enable farmers to better assess input usage, irrigation efficiency, waste practices, and compliance with cultivation practices. Sustainability indicators are not only used to measure performance but also to identify which practices need the most improvement (Devkota et al., 2022). This contributes to improvements in finite resource management, reduces negative environmental impacts, and strengthens environmental sustainability in the context of rice cultivation in Malaysia. In terms of the economic dimension, MySRI addresses economic sustainability challenges such as single-income households, limited accounting knowledge, and vulnerability to economic shocks that affect the long-term economic resilience of rice farmers. Therefore, the development of MySRI encourages farmers to improve operational management, financial awareness, proper resource utilisation, and long-term financial planning. Additionally, the sustainability index enables the improvement of economic sustainability practices by identifying strengths and weaknesses, informing decision-making, benchmarking, and encouraging long-term sustainability practices (Malak-Rawlikowska et al., 2021). Furthermore, helping farmers document and present sustainable practices to meet market and society expectations, maintain market access, and potentially improve economic opportunities through sustainable market premiums (Dong et al., 2016). Through MySRI, contribute towards farmer economic resilience and improved sustainability practices over the long term. On social sustainability, which has been integrated into MySRI, address social problems such as farmer well-being, safety and health, and capacity development. MySRI improves by promoting awareness of occupational safety, capacity development, and their welfare. Brennan et al. (2023) report that sustainability indices help identify risks and guide policies to address social vulnerability, such as improving infrastructure and community connectivity. Moreover, these assessment tools identify social sustainability issues as critical barriers that encourage agricultural extension officers to anticipate these issues (Mujio et al., 2025).

Based on the identified weak sub-indicator in the MySRI assessment, highlight that unsustainable practices among rice farmers in Malaysia still require attention and improvement. Therefore, MySRI addresses the weak sub-indicator by providing data-driven information for rice farmers and agricultural extension to assist them in recognising sustainability gaps and prioritising suitable improvement strategies. However, MySRI does not prescribe specific actions that farmers must follow, as the selection of appropriate, feasible, and practical improvement strategies depends on the farmers and relevant agricultural agencies based on local conditions and suitability. The identified weak sub-indicators may be addressed through the suggested practices for their respective sustainability sub-indicators. Therefore, MySRI indirectly improves sustainability practices by informing rice farmers and agricultural extension services about suitable strategies.

5.5.1 MySRI With Malaysian Past Index

Comparison with past development indices focusing on Malaysian agriculture indicated that MySRI improved the sustainability index model structure by integrating 3 sustainability dimensions, a theoretical sustainability framework, operational, measurable indicators, a multi-normalisation approach, and weighting and aggregation adaptation. Table 5.5 shows the summaries of past index structures and MySRI. There are 2 rice indices focusing on one dimension (Kamaruddin & Abd. Rashid, 2025; Mohamed et al., 2016), 1 rice index focusing on 3 dimensions (Ajidasile, 2015), 1 palm oil index focusing on 3 dimensions (Jamaludin et al., 2018), 1 vegetable and fruits index focusing on 3 dimensions (Keyvanfar et al., 2020), and 1 vegetable index focusing on 3 dimensions (Taylor et al., 1993). MySRI expanded the past rice index's assessment of dimensions, focusing on environmental, economic, and social dimensions and anchoring them in three intersections of the sustainability concept (Barrier, 2017; Purvis et al., 2019), which the past rice index did not explicitly address.

Table 5.5
Summaries of Past Index Structure and MySRI

Index Name/ Author/ Crop	Framework Based	Dimension	Measurable variable approach	Normalized approaches	Weightage & aggregation
Keyvanfar et al. (2020)./Sustainable Urban Farming Index Assessment (SUFIA)/ Vegetable & fruits	Not explicitly mentioned; adapt based on the sustainability framework	Economic, Environmental and Social	Literature review and survey	Summing entries in columns and dividing by the sum to yield a normalised score.	Analytical Hierarchy Process (AHP) and Weighted Sum Method (WSM).
Jamaludin et al. (2018)./Palm Oil Mill Sustainability Index (POMSI)/ Oil palm	Oil palm sustainability framework	Economic, Environmental and Social	Literature review and survey	Proximity-to-Target (PTT) measures distance to policy targets (Scale 0–100).	Equal weighting & Additive aggregation
Taylor et al. (1993). Farmer Sustainability Index (FSI)/ Cabbage	Not explicitly mentioned; adapt based on the sustainability framework	Environment	Literature review and survey	Linear adjustment to 0–100 scale (Total score * 100/82).	Expert census and subjective team judgment. Simple addition
Ajidasile (2015). Agricultural Sustainability Index (ASI). / Rice	Not explicitly mentioned; adapt based on the sustainability framework	Economic, Environmental, and Social	Literature review and survey	Adjusted to a 0–100 scale.	Perceived influence on sustainability (positive/negative values). Not explicitly mentioned; aggregation.
Mohamed et al. (2016). Farmer Sustainability Index (FSI)/ Rice	Rice Check Guideline	Environment	Direct adaptation	Recalibrated scores to a range of 0–100 based on discrete categories.	Perceived influence on sustainability (positive/negative values). Not explicitly mentioned: aggregation
Kamaruddin & Abd. Rashid	Rice Check Guideline	Environment	Direct adaptation	Percentage conversion (Total Score /	Binary scoring (1 if performed, 0

(2025)/ Sustainable Farm Management Index (SFMI)/Rice				68 * 100) on a 0–100 scale.	if not). Percentage conversion of total recalibrated scores.
Malaysian Rice Sustainable Index (MySRI)/ Rice	Local and international framework	Economic, Environmental, and Social	Literature review, interview, survey	Equal weightage	Additive aggregation

In addition, the adaptation or creation of a sustainability framework. Only the POMSI index is based on a sustainability framework or guideline in the oil palm industry (Jamaludin et al., 2018), out of 6 indices in Malaysian agriculture. 3 indexes focus on paddy; only 2 are based on the Malaysian Rice Check Guideline (Kamaruddin & Abd. Rashid, 2025; Mohamed et al., 2016), and one paddy index does not mention a sustainability framework (Ajidasile, 2015). As a result, the sustainability index becomes vague, disconnected, inconsistent, and unable to guide policy, monitoring, and improvement across environmental, economic, and social dimensions (Wu & Wu, 2012). Therefore, the MySRI basis was established on the basis of MSPO, SAFA, SRP, RSPO, and MyGAP to align with the sustainability concept. Subsequently, MySRI has established operational, measurable indicators from finalised criteria and indicators, with sub-indicators, using a literature review, interviews, and surveys. Compared to previous rice indices, 2 indices directly adapted indicators based on the Malaysian Rice Check Guideline (Kamaruddin & Abd. Rashid, 2025; Mohamed et al., 2016) and literature review and survey approaches in determining measurable variables (Ajidasile, 2015). Research on the POMSI, SUFIA, and FSI indices established measurable indicators through a literature review and survey approaches (Jamaludin et al., 2018; Keyvanfar et al., 2020; Taylor et al., 1993). Because of this, the method for establishing measurable indicators in MySRI used multiple approaches to ensure that the sustainability assessment reflected the concept of sustainability and strengthened its reliability.

Other than that, MySRI has expanded the use of multiple normalisation techniques in index development. The previous index focused only on one normalisation technique, based on the study's objective. This is because measuring sustainability was complex, with different units, scales, and variable data structures. Unlike the 3-Rice index (Ajidasile, 2015; Kamaruddin & Abd. Rashid, 2025; Mohamed et al., 2016), Proximity to Target has been adapted because this method has a threshold value integrated in the equation, which directly benchmarks the value of the variable calculated, giving the outcome of the calculation considering the maximum and minimum values. The opposite is the case for the adaptation of a categorical scale in MySRI, as it facilitates the transformation of Likert-scale variable data. This happens because assessing farmers' sustainability is challenging due to a lack of available data on intended metrics. Therefore, ensuring the availability of data, the created Likert-scale variable was suitable for aligning with the sustainability assessment framework. For such situations, MySRI has improved the use of normalisation techniques, which are adapted in index creation with multiple techniques used.

In addition, MySRI has improved the use of aggregation approaches and weighting in index construction. The Rice index in Malaysia only focuses on simple scoring weightage approaches based on perceived influence on sustainability (positive/negative values) (Ajidasile, 2015; Kamaruddin & Abd. Rashid, 2025; Mohamed et al., 2016. While MySRI uses equal weighting, established by starting from dimensions to criteria. The result is a balanced level of importance on all dimensions, criteria, indicators, and sub-indicators. Additionally, MySRI uses additive aggregation approaches that are directly influenced by normalisation and weighting techniques, rather than the simple addition of individual practice component scores from the rice index.

5.5.2 Index Mathematical Algorithm Procedure Implication

Using the equal-weighting technique, the MySRI assessment results were strengthened. In the study, the environmental (80.14%), economic (79.76%), and social (82.84%) dimensions contributed equally to an overall sustainability score of 80.91%. This shows that no single dimension dominates the overall index, although the social dimension recorded the highest performance. Therefore, equal weighting reflects the normative assumption that environmental responsibility, economic viability, and farmer well-being are equally important in sustainable rice cultivation. In addition, additive aggregation allows stronger performance in one dimension to compensate for weaker performance in the other. In this index's results, although the economic dimension score is slightly lower, it does not result in a significant decrease in the overall sustainability rating because the social and environmental dimensions remain strong. This compensatory structure reflects a farm-level trade-off in which improvements in a practice often occur in stages rather than being uniform across multiple dimensions. Ochieng et al (2022) stated that complementarities and trade-offs exist among different sustainable agricultural technologies and that indicator farmers did not uniformly apply the practices.

For the use of Proximity to target (PTT), ensure that heterogeneous indicators measured in different units, such as yield, input costs, pesticide and fertiliser consumption, and categorical variables, have been converted to a comparable scale before aggregation. Without this conversion, indicators that have a larger numerical range will dominate the MySRI score or make sustainability interpretation difficult. In this study, normalisation has converted each indicator into a bounded scale, thereby eliminating differences between farmers. This shows an overall sustainability score of 80.91%, reflecting relative performance in the IADA BLS and the opening of the pure ecological threshold. Thus, MySRI functions as a comparable tool, identifying strengths and weaknesses among rice farmers while preserving fairness across multiple measurable indicators.

The additive aggregation technique combines dimension scores into a composite sustainability index by summing weighted components. Environmental (80.14%), economic (79.76%), and social (82.84%) scores result in an overall sustainability score (80.91%). This method compensates for poor performance on certain criteria with high performance on others, thereby enabling trade-offs (Yusop et al., 2015). A slightly lower pesticide input criteria score did not disproportionately reduce the overall index, as the social and economic dimensions remained strong. These compensatory structures depict actual farm-level situations, in which sustainability improvement occurs gradually and unevenly across different dimensions. Compared to non-compensatory techniques, additive aggregation provides a balanced and interpretable measurement suitable for assessing sustainability performance in rice cultivation systems.

5.5.3 Practical Application of MySRI

The development of the Malaysian Sustainability Rice Index (MySRI) provides a practical tool to improve sustainable agricultural practices in rice cultivation. As a sustainability measurement tool, MySRI also supports sustainability policy development, monitoring systems, and strategic intervention focused on rice farmers.

The evaluation results for this index indicate various sustainability problems across environmental, economic, and social dimensions that are interconnected and affect long-term sustainability and food security. Therefore, MySRI translates a complex sustainability system into measurable insights that support systematic sustainability management and data-driven decision-making in Malaysian rice cultivation.

MySRI supports policy development by providing measurable insights into the sustainability performance of rice farmers. Based on identified weak sub-indicators such as excessive agrochemical use, single-source income, and weak record-keeping, MySRI enabled agricultural agencies and ministries to identify critical unsustainable practices among rice farmers. This sustainability insight enabled improvements to agricultural policy and sustainable programs based on farmers' real needs. Past studies have demonstrated that sustainability indices support evidence-based policymaking by identifying priority intervention areas, weak sectors, and targeted resource allocation (Fajardo-Gonzalez et al., 2025; Vecchione, 2010). One way is to identify excessive agrochemical inputs, which can suggest development towards environmentally friendly practices and input management programs, and increase incentives for biological inputs. Again, weak income diversification encourages more intensive entrepreneurship programs and income-support initiatives to further strengthen rice farmers' economic resilience. Therefore, MySRI improves policy development by providing measurable sustainability information for targeted, sustainability-focused practice initiatives in Malaysian rice cultivation.

In addition, MySRI functions as a sustainability monitoring system that allows sustainability performance among rice farmers to be assessed systematically over the intended timeframe. Based on periodic sustainability assessments, agricultural agencies or rice farmers enabled monitoring of changes in sustainability performance across different timeframes, irrigation and granary areas. These indices allow for tracking trends, comparing performance, assessing weak sustainability dimensions, and evaluating the effectiveness of agricultural policy over time (Magrini & Giambona, 2022). In fact, it can be used to evaluate the past or current performance of a monitored system or to predict its future behaviour (Alonso-Martínez et al., 2024). Therefore, by comparing sustainability performance scores over time, MySRI enabled agricultural agencies to identify improvement trends, detect declines, and evaluate the effectiveness of sustainability practices and initiatives implemented on rice farms. Therefore, MySRI strengthens monitoring practices by providing measurable, operational assessment tools to support continuous evaluation of sustainability in the Malaysian rice industry.

In addition, MySRI supports targeted sustainability intervention strategies to identify specific weak practices in rice farming that need improvement. The identified weak sustainability on MySRI enabled extension officers and rice farmers to design targeted intervention programs or strategies based on the problems faced by rice farmers. Past studies stated that indices provided evidence-based information, allowing policymakers and agricultural agencies to prioritise specific intervention strategies and implement sustainability improvements (Sabiha et al., 2016). This can be seen in rice farmers who perform poorly in input management, who can prioritise environmentally friendly agricultural training, such as organic fertiliser promotion programs and advanced pest management practices. Meanwhile, weak economic performance can focus on intervention programs such as capacity development in finance, farming, and entrepreneurship. Finally, MySRI demonstrates the measurement of sustainability concepts and the strengthening of policy development, targeted monitoring, and interventions in the Malaysian rice cultivation system.

5.5.4 Global Relevance of MySRI

MySRI was developed specifically for Malaysian rice cultivation; the methodology used in its development enabled adaptation to larger and other agricultural sustainability assessment contexts. The integration of environmental, economic, and social sustainability dimensions provides a structured variable for evaluating sustainability performance at the farm level. Thus, the integrated multidimensional variable framework used in MySRI can be used directly as a reference or to establish new variables in the development of other index contexts, ensuring that the sustainability concept is applied across the index, as the sustainability dimensions are interrelated. In addition, the process of developing the MySRI basis and variables uses a literature review, interviews, and content validity methods to ensure relevance to local farmers in Malaysia. Therefore, these methods can be used directly in future index development to ensure that their basis and index criteria are relevant, feasible, and suitable for the desired assessment context. In addition, the structured index-development mathematical procedure used in MySRI includes normalisation, weighting, and aggregation approaches relevant for adaptation to other new index development. This mathematical procedure is important to improve comparability, consistency, and transparency in sustainability assessment tools (Gan et al., 2017; Usubiaga-Liaño & Ekins, 2024; Zhou et al., 2012). As such, these mathematical procedures may be adapted in future index development studies for other crops, sectors, or regions that require measurable, multidimensional, and operational approaches to sustainability evaluation.

5.6 Chapter Summary

This chapter discusses the study's findings in relation to three research objectives. The discussion combines theoretical grounding, methodological justification, and interpretation of assessment results to show the robustness and applicability of the developed index. The proposed sustainability criteria are developed in line with established international and local agricultural frameworks and are organised into environmental, economic, and social dimensions. This discussion demonstrated that the criteria were conceptually aligned with sustainability theory and contextually relevant to rice farming in Malaysia. Based on expert validation, the framework has been refined to improve clarity, contextual relevance and measurability. The refinement reduced redundancy and strengthened the validity of the final criteria, which consist of 20, 35 indicators, and 53 sub-indicators. Thus, these approaches enhanced the credibility of the developed index, which reflects both the theoretical foundation and practical farming practices. The assessment of rice farmers using the index produced an overall sustainability score of 80.87%, indicating a strong sustainability rating among rice farmers under IADA BLS supervision. Each dimension also shows a strong sustainability rating. However, there are still sub-indicators that receive low ratings and need improvement regarding rice farmers' practices and adoption. Next, this discussion explains the use of algorithms such as normalisation, weighting and aggregation. The normalisation used ensures comparability across different indicator scales, and equal weighting ensures that dimensions, criteria, indicators, and sub-indicators are balanced. The use of additive aggregation allows the combination of multiple indicators into a composite score while maintaining interpretability and transparency. Despite the various algorithmic methods available, the chosen method ensures transparency and provides a practical tool for farm-level sustainability assessment.

CHAPTER 6
CONCLUSION

6.1 Conclusion

This thesis has developed a comprehensive, context-specific sustainability index for Malaysian rice farmers that considers environmental, economic, and social dimensions. The foundation framework for the index aligns with the local agriculture framework, international and local regulations, and expert opinion. In the overall objective of this thesis, this study has successfully identified, improved, and developed a measurable assessment tool, the Malaysian Sustainable Rice Index (MySRI). The index has been used to assess the real-world sustainability of rice farmer practices at IADA BLS Selangor, Malaysia.

The first objective's findings confirm that the international and local agricultural frameworks or criteria provide a strong conceptual direction. However, several of its components or criteria lack strong alignment with the current structure of the Malaysian cultivation system, focusing on rice farmers, crop management by granary-area agencies, and local practices. Objective 2 has produced 20 criteria and 58 basic sub-indicators for assessing the MySRI index through expert validation, which were subsequently refined to ensure they are measurable, rice-farmer-specific, and feasible to implement in the Malaysian region. Finalised measurable criteria, indicators, and sub-indicators for the sustainability assessment of Malaysian Rice cultivation require context-specific, multidimensional, and measurable variables that represent rice cultivation practices and current local conditions. Therefore, addresses the limitation of previous sustainability indices that are single-dimensional, weakly integrated, and insufficiently aligned with sustainability concepts. In addition, unlike previous indices that focused on selected dimensions or the broader agricultural context, MySRI integrates 3 dimensions into a unified, farm-level assessment tool adapted to Malaysian rice cultivation practices.

Finally, Objective 3 has created the MySRI index by assessing farmer sustainability at IADA BLS, Selangor. The assessment demonstrates an overall index score, with dimensions exceeding 80% sustainability performance, indicating “Good” on the SAFA framework scale. While in sub-indicator component, the score is excellence in areas such as Drying and stalk visualization, 2) Weed management, 3) Land preparation schedule, empty field, and field supervision, 4) Burning, 5) Wellbeing status, 6) Paddy Farmers' Capacity Level, 7) Tools and equipment, 8) Utilization of Government and NGO Support Programs, 9) Informed irrigation water issues, 10) Personal protective equipment (PPE), 11) Receive seed from certified seed provider, 12) Disease management, 13) Mollusc management, 14) Rodent management, 15) Transport storage, 24-hour yield transfer timeframe and representative of selling yield, 16) Training of pesticide applicators, and 17) Re-entry time. However, the five criteria that indicate weak performance below 40% that need improvement are 1) Diversification of income, 2) Record of Contracts and Agreements, 3) Organic pesticide (Natural ingredients), 4) Amount of biological fertiliser consumption, and 5) Amount of chemical pesticide consumption. This indicates that there was an area needing improvement in rice farmers' practices. The identified weak sub-indicator indicated that MySRI acts as a decision-support tool enable sustainability monitoring, policy development, and targeted improvement.

Overall, the study concluded that sustainability practices in Malaysian rice cultivation are increasing, but there are still areas for improvement. The majority of the criteria were performed well by rice farmers, but some showed weak performance. MySRI serves not only as an assessment tool but also as a tool to identify weak areas that require deep attention to improve. This thesis contributes to an empirically validated, practically applied framework that enhances Malaysian commitment to sustainable agricultural practices and improves food security.

6.2 Implication of The Index Development

MySRI provides a context-specific assessment tool for rice farmers and agricultural agencies. One of the preferred tools for farmers and agricultural agencies to assess rice farmers. The study's results focus on weak sub-indicators; farmers and the Government can develop appropriate action plans to improve weak-performing sub-indicators. In addition, the MySRI score can serve as a benchmark for farmers or the government to compare with other assessment tools, thereby supporting the evaluation of those tools.

At the government level, MySRI can be a monitoring framework for IADA BLS or other rice agencies. The index provides a multidimensional sustainability assessment that captures environmental compliance, economic resilience, and social responsibility, enabling farmers to conduct a comprehensive evaluation of rice cultivation rather than focusing solely on production-based metrics such as yield and input costs. The index enables these agencies to view sustainability status from a different perspective. The results of this assessment index data can be used to help agricultural extension engaged in monitoring activities (Sabiha et al., 2016). In addition, this index supports targeted intervention strategies, such as addressing the worst indicator identified in the study, where pesticide consumption and income diversification are actionable areas for agricultural extension to engage with. Thus, this agency could design an owned capacity development program aligned with the identified weaknesses.

In addition, this index may inform policy interventions, such as subsidies for sustainability, grants, or enhancements to certification, which can be combined with MySRI results as a benchmark. This integration could encourage step-by-step improvement without imposing heavy compliance requirements and could be implemented directly. On the contrary, MySRI supports Malaysia's agricultural policy goals of food security and sustainable agriculture. This index could serve as a bridge between diverse sustainability goals and robust initiatives, translating this concept into measurable, actionable, and monitorable data.

On the other hand, it also provides expectations on the potential impact of practices in the near future through behaviour change. In private industry, they can identify which agricultural inputs are suitable for rice farmers, encouraging them toward sustainable agriculture. In addition, it invites private industry to assess appropriate input prices for rice farmers, as MySRI results show that organic inputs need to be priced differently to attract rice farmers. In addition, academic and public researchers can use MySRI results as benchmarks for future studies in Malaysia, with a focus on both overall and dimension-specific outcomes.

6.3 Contribution of The Index Development

There are several contributions from this development index that can be stated in four topics, namely a) theoretical contributions, b) methodological contributions, c) empirical contributions, and governance contributions.

6.3.1 Theoretical

The development of MySRI provides a conceptual sustainability framework explicitly designed for rice growers in Malaysia, grounded in three intersecting pillars: environmental, social, and economic. Additionally, broaden the conceptual application of multi-dimensional sustainability assessment in Malaysian rice cultivation by integrating environmental, economic and social dimensions into a context-specific farm-level sustainability index tool. Thus, the study contributes validated criteria from the five sustainability frameworks and aligns with current practices in Malaysia. The current sustainability framework, which MyGAP focuses more on the environmental and social dimensions than the MySRI framework, adds new economic dimensions, providing new insights into the sustainable practices of rice farmers.

6.3.2 Methodological

In addition, MySRI contributed to the development of the index, including creating a more transparent, replicable, and refined set of criteria, indicators, and sub-indicators. The use of Proximity to Target (PTT) and categorical normalisation strengthens the comparability and integration of variables measured on different units and scales, thereby improving multidimensional sustainability assessment in Malaysian rice cultivation. Further, the aggregation technique was adapted to additive aggregation to facilitate the interpretation of calculated variables from raw data through normalisation and weighting. In developing the assessment basis (sustainability criteria or framework), MySRI is guided by the sustainability framework and draws on expert judgment. Previous studies on Malaysian rice did not develop a new framework; instead, they used the Malaysia Rice Check Guideline as the basis for assessment. Therefore, the MySRI structure, which demonstrates a multidimensional sustainability concept, can be operationalised into measurable farm-level sustainability through structured mathematical algorithms.

6.3.3 Empirical

MySRI contributes with generated evidence-based information capable of identifying sustainability strengths and weaknesses among rice farmers that allows for more targeted sustainability monitoring and intervention planning. Apart from providing new assessment tools to paddy farmers and agricultural officers, MySRI also promotes awareness of the importance of sustainable agriculture in paddy cultivation in Malaysia.

6.3.4 Governance

From a governance perspective, MySRI provides a structured sustainability benchmarking and monitoring tool that enables evidence-based agricultural policy development, sustainability governance, and long-term sustainability planning for Malaysian rice. Moreover, encouraging rice farmers and agriculture officers to adapt governance practices in their operations to increase efficiency.

6.4 Limitations of MySRI Development

There are several shortcomings in the developed MySRI, including the framework-based approach, the framework establishment approach, the index algorithm, the assessment location, sample size, data sources, and sensitivity analysis, as shown in Table 6.1 below. This is due to MySRI focusing only on establishing sustainability criteria and indicators based on 5 sustainability frameworks. As a result, the selected criteria and indicators do not represent the overall global criteria and indicators for rice cultivation. Therefore, 5 frameworks may not be sufficient to account for the various factors within each criterion. In addition, the criteria and indicator establishment method relies solely on a general literature review; as a result, important and appropriate criteria and indicators may be omitted from the review of the sustainability framework.

Table 6.1
Summaries of MySRI With Past Index

Index	MySRI	SFMI	POMSI	ASI
Author	Thesis owner	Kamaruddin & Abd. Rashid (2025)	Jamaludin et al. (2018).	Christo et al. (2025)
Country	Malaysia	Malaysia	Malaysia	Brazil
Crop	Rice	Rice	Oil Palm	Multi crop
Framework base	SAFA, MSPO, RSPO, MyGAP, SRP	Rice Check Guideline	Oil palm sustainability frameworks	Sustainable Agriculture Matrix
Framework established approach	Literature review, interview,	Direct adaptation	Literature review, questionnaire	Literature review

	questionnaire			
Dimension	Environment, economic, social	Environment	Environment, economic, social	Environment, economic, social
Index algorithm approach	Normalisation, weighting, additive aggregation	Normalisation, weighting, Simple aggregation	Normalisation, weighting, additive aggregation	Normalisation, weighting, arithmetic and geometric aggregation
Sensitivity and uncertainty analysis	Not conducted	Not conducted	Not conducted	Not conducted
Assessment sample	45 rice farmers	500 rice farmers	4 palm oil mills	5,570 municipalities
Assessment scale	Farm level	Farm-level	Mill operation level	Regional level
Assessment location	IADA BLS, Selangor Malaysia	IADA BLS, MADA, KADA, Malaysia	Malaysia	Brazil municipalities
Assessment data source	Questionnaires and secondary data	Questionnaires	Secondary data	Secondary data

On the other hand, in the expert judgment approach, relying solely on one-to-one interviews to obtain expert feedback is time-consuming, as it requires analysing each expert's data, and the resulting data may not be sufficiently robust to yield truly appropriate criteria. In the index algorithm used, equal weighting may not represent the true importance of indicators in the context of rice cultivation in Malaysia. This is because the importance of indicator weight is influenced by the effect of the negative dimension faced by the stakeholder. Moreover, the study location and sample were limited to one granary area and tested the operational index. Therefore, the study's results cannot be generalized to all farmers in Malaysia.

In addition, three agencies supervise rice cultivation in Malaysia, each located in a different area influenced by the local climate. Next, the data collected for the assessment are based solely on farmers' opinions and are quantitatively analysed and verified against the IADA BLS for several sub-indicators. In auditing, qualitative and quantitative approaches are required to obtain robust data that can be verified with each other. For uncertainty and sensitivity analysis, the literature also lacks a final index approach; it only suggests using the index as a reference basis, as has been done in other studies. Therefore, MySRI may exhibit lower robustness in its algorithmic results due to the lack of implemented uncertainties and sensitivity analysis, similar to the previous rice index developer.

6.5 Recommendations

This recommendation focuses on five areas: policy and government, private stakeholders, extension services, index structure, and the local community, as well as future research directions.

6.5.1 Integration of Multiple Frameworks

Future research is recommended to integrate various sustainability frameworks in agriculture, such as the RISE (Response-Inducing Sustainability Evaluation) framework, the MASC (Multiattribute Assessment of Sustainability of Cropping Systems) framework, the LADA (Land Degradation Assessment in Drylands) tool, and the SMART (Sustainability Monitoring and Assessment Routine) framework. By incorporating these frameworks, the future foundation of the development index could be more comprehensive, strengthening alignment with sustainability concepts and practices while considering context-specific criteria for the intended study.

6.5.2 Integration of Multiple Literature Review Approaches

Furthermore, future studies could adapt multiple literature review approaches, such as systematic literature review, general literature review, and integrative literature review, with modifications that focus on the document review of sustainability criteria and indicators. This integration could strengthen the validity and relevance of the proposed foundation of the development index.

6.5.3 Integration of Qualitative and Quantitative Approaches in The Validation of Criteria and Indicators

Future index developer encourages the adoption of qualitative and quantitative approaches, such as the adapted Delphi method in combination with interviews, focus group discussions with intended stakeholders, and a quantitative survey to finalise the proposed criteria, indicators, and sub-indicators. By adapting this approach, robust, transparent, and reliable variables may be highly adaptable for other researchers.

6.5.4 Analytic Hierarchy Process (AHP)

Future research is encouraged to adapt the Analytic Hierarchy Process (AHP) to determine the weights of important variables. This approach could enhance the relevance of the adopted variable and enable the calculated value to be integrated into normalisation and additive aggregation. Moreover, enabled the selected variable to represent the actual state of sustainability in the intended research context.

6.5.5 Integration of Aggregation and Adaptation of Uncertainty and Sensitivity Analysis

Future index developers could try to integrate geometric and additive aggregation into the calculation of the variables. By adapting these approaches, future research can provide additional options for representing their index results in terms of an overall score and the specific scores of the intended variables being measured. Thus, enabled comprehensive analysis and holistic data presentation in the identified weakness and strength areas, specifically. Furthermore, future research should conduct uncertainty and sensitivity analyses, depending on the focus, resources, and industry translation used to present the transparency and robustness of the developed index. With this analysis, future developers could be aware of outliers in the index calculation and consider modifications to normalisation, weighting, and aggregation.

6.5.6 Policy and Government

The government is recommended to expand MySRI to a national scale as a monitoring tool to see the overall sustainability performance of rice farmers. Moreover, the government is recommended to create a general agricultural sustainability framework applicable to all agricultural sectors in Malaysia, similar to the SAFA framework. In addition, a special framework was created for each stakeholder in the rice industry to assess their sustainability. Next, create a standard threshold value for each criterion; in the assessment, there is a sub-indicator for pesticide amount without a threshold value to use as a reference. Therefore, the researcher has used the mean (average) from the raw data. Next, provide additional incentives for organic pest control and organic fertilisers to farmers who get a high index score. In addition, provide subsidies to rice farmers with a high index score.

6.5.7 Private Stakeholder

Private stakeholders are recommended to promote greater use of organic inputs among rice farmers. Balance the sale of agrochemicals and agro-organic inputs to attract rice farmers to sustainable practices. In addition, encouraged to have at least a written agreement between rice farmers and private stakeholders on the purchase of production inputs for a loan with a guarantee by the government (have a higher index score).

6.5.8 Agricultural Officer and Farmer

In the MySRI index assessment, agricultural officers and farmers should focus on the use of organic inputs for paddy crops, the balanced use of synthetic inputs, workplace safety, and financial management. Agriculture officers can also modify the criteria and indicators to meet their needs and requirements, in line with the concept of sustainability. In fact, creating mobile apps or online forms helped farmers track their own progress in sustainability performance.

6.5.9 Integration of Qualitative and Quantitative Assessment

Future index developer suggested considering the integration of qualitative and quantitative data collection. By adapting the two approaches, the data collected during the assessment may strengthen the validity of the raw data collected. Integration of data collection approaches such as interviews, surveys, observations, and secondary data review enables the index developer to obtain reliable data by triangulating these data to present the actual practices conducted by the intended sample.

6.5.10 Local Community

Local communities, such as farmer groups and local non-governmental organisations (NGOs), are encouraged to use MySRI assessment insights to create learning discussions or share insights on sustainability challenges and practices. Next, NGOs can use MySRI to assess rice farmers' agricultural practices as a third-party assessor.

6.5.11 Future Research Direction

The study on data could expand the use of MySRI or create a new index by assessing sustainability in other granary regions or agencies. Allowing for comprehensive comparisons across Malaysia. However, expanding to Sabah and Sarawak requires reviewing the criteria and indicators to be used, ensuring they align with the rules, regulations, and environmental considerations. On the other hand, the proposed development of a new index, or MySRI, should be combined with a digital dashboard platform to enhance real-time monitoring capabilities. Incorporating data from remote sensing technologies and secondary data from agencies could further deepen the outcome and improve data reliability. Further, expanding the assessment timeframe to 5 years or to seasonal cultivation could improve data comparability.

REFERENCES

Ab Rahman, M. F., & Ab Rahim, S. F. (2023). Dynamic of Diversity of Rate Establishment in the Practice of Agricultural Zakat Collection In Malaysia. Kajian Malaysia, 41(2), 1-20.

Abbasi, A., Sajid, A., Haq, N., Rahman, S., Misbah, Z. T., Sanober, G., ... & Kazi, A. G. (2013). Agricultural pollution: an emerging issue. In Improvement of crops in the era of climatic changes: Volume 1 (pp. 347-387). New York, NY: Springer New York.

Abdar, Z. K., Amirtaimoori, S., Mehrjerdi, M. R. Z., & Boshrabadi, H. M. (2022). A composite index for assessment of agricultural sustainability: the case of Iran. Environmental Science and Pollution Research, 29(31), 47337-47349.

Abdul Majid, N., Ramli, Z., Md Sum, S., & Awang, A. H. (2021). Sustainable Palm Oil Certification Scheme Frameworks and Impacts: A Systematic Literature Review. Sustainability, 13(6), 3263.

Abdul-Hakim, R., Ismail, R., & Abdul-Razak, N. A. (2010). The impact of social capital on quality of life: evidence from Malaysia. European Journal of Economics, Finance and Administrative Sciences.

Abdullah, A. R., Bajet, C. M., Matin, M. A., Nhan, D. D., & Sulaiman, A. H. (1997). Ecotoxicology of pesticides in the tropical paddy field ecosystem. Environmental toxicology and chemistry, 16(1), 59-70.

Abdul-Rahaman, A., & Abdulai, A. (2020). Vertical coordination mechanisms and farm performance amongst smallholder rice farmers in northern Ghana. Agribusiness, 36(2), 259-280.

Abed, N., Kakolaki, M. B., Ramesh, M. V., Sankarannair, S., Murugan, R., Soundharajan, B. S., & Pushpalatha, R. (2025). Assessing farm-level agricultural sustainability in India: A comparative study using a mixed-method approach. Agricultural Systems, 224, 104223.

Abeysekera, I. (2022). A framework for sustainability reporting. Sustainability Accounting, Management and Policy Journal, 13(6), 1386-1409.Sustainability Science, 6(2), 233-246.

Abidin, I. S. Z., Haseeb, M., Islam, R., & Chiat, L. W. (2022). The role of rural infrastructure, labour and capital investment on the rice production in Malaysia. AgBioForum, 24(1), 50-58.

Acquaye, A. (2025). Operational research for sustainability: a synthesis of methods, applications and challenges. Journal of the Operational Research Society, 1-35.

Adeoye-Olatunde, O. A., & Olenik, N. L. (2021). Research and scholarly methods: Semi-structured interviews. Journal of the american college of clinical pharmacy, 4(10), 1358-1367.

Adıbelli, D., Kırca, N., & Özkan, İ. (2022). The problems of women working in greenhouse agriculture in rural area in Turkey: A phenomenological study from health and social perspective. Health & Social Care in the Community, 30(1), 203-211.

Adnan, A. A., Ashari, M. A., Baskaran, S. M., Mahamad, S. S., Nawi, N. M., & Zakaria, M. R. (2024). Farmers Awareness and Acceptance of Biopesticides Application for Pest and Disease Management. AgroTech-Food Science, Technology and Environment, 3(2), 77-88.

Adu, P. (2019). A step-by-step guide to qualitative data coding. Routledge. 97-98

Afodu, O. J., Afolami, C. A., Akinboye, O. E., Ndubuisi-Ogbonna, L. C., Ayo-Bello, T. A., Shobo, B. A., & Ogunnowo, D. M. (2019). Livelihood diversification and its determinants on rice farming households in Ogun State, Nigeria. African Journal of Agricultural Research, 14(35), 2104-2111.

Ahamad, R., Yusop, Z., Salim, M. R., Mohd Yusoff, A. R., Aris, A., & Noor, Z. Z. (2015). Environmental Performance Index for Malaysia 2014. Johor, Malaysia: Ministry of Natural Resources and Environment.

Ahmad, P. S. S. (2019). Benih padi sah sukar diperoleh. Berita Harian. Retrieved from https://www.bharian.com.my

Ahmad, Z. A., Tan, S. C., Soh, P. J., Abdullah, A. H., Ahmad, M. I., & Daud, S. (2024). Durio Zibethinus L Plantation Intelligent Web-Based Irrigation System using Fuzzy Logic (DuWIMS) Based on IoT.

Aithal, A., & Aithal, P. S. (2020). Development and validation of survey questionnaire & experimental data–a systematical review-based statistical approach. International Journal of Management, Technology, and Social Sciences (IJMTS), 5(2), 233-251.

Ajidasile, O. H. (2015). Development Of Rice Production Sustainability Index In Mada, Malaysia

Alabi, O., & Bukola, T. (2023). Introduction to Descriptive statistics. In Recent advances in biostatistics. IntechOpen.

Alam, M. M., Ibrahim, Y., & Mia, M. S. (2020). Climate change impacts on yield and financial performance of agro-plantation companies in Malaysia. International Journal of Postharvest Technology and Innovation, 7(1), 15-28.

Alam, M. M., Siwar, C., Talib, B., & Jaafar, A. H. (2013). Climatic change and the socioeconomic sustainability of the paddy farmers in Malaysia. Alam, MM, Siwar, C., Talib, B., and Jaafar, AH, 163-166.

Alaoui, A., Barão, L., Ferreira, C. S., & Hessel, R. (2022). An overview of sustainability assessment frameworks in agriculture. Land, 11(4), 537.

Ali, A., Raza, A., Malik, A., Shabbir, M., Sarwar, N., & Muzammal, H. (2025). AI and IoT Solutions for Food Security and Agriculture. In Enhancing Automated Decision-Making Through AI (pp. 177-210). IGI Global Scientific Publishing.

Ali, J., Yusof, N., & Abd. Aziz, F. S. (2018). Factors influencing farmer's perceptions and behavior toward pesticide use in Malaysia. International Journal of Social Economics, 45(5), 776-792.

Ali, N. I. M., Ibrahim, N. I., Aiyub, K., & Kasavan, S. (2020). Pelaksanaan Amalan Pertanian Baik (GAP) dalam kalangan pesawah padi di Sekinchan, Sabak Bernam, Selangor (Implementation of Good Agricultural Practices (GAP) among paddy farmers in Sekinchan, Sabak Bernam, Selangor). Geografia, 16(3).

Ali, N. I. M., Ibrahim, N. I., Aiyub, K., Kasavan, S., Choy, L. K., & Siron, R. (2021). Challenges in implementation of MyGAP among paddy farmers. Malaysian Journal of Society and Space, 17(4).

Allen, C., Metternicht, G., & Wiedmann, T. (2018). Initial progress in implementing the Sustainable Development Goals (SDGs): A review of evidence from countries. Sustainability science, 13(5), 1453-1467.

Alonso-Martínez, D., Jiménez-Parra, B., & Cabeza-García, L. (2024). Theoretical framework to foster and assess sustainable agriculture practices: Drivers and key performance indicators. Environmental and Sustainability Indicators, 23, 100434.

Al-Thani, M. J., & Koc, M. (2024). Development of an Alternative Sustainable Economy Index: Integrating Multidimensional Sustainability Features. Sustainability, 16(18), 7956.

Anam, M. H., Sulaiman, A., Othman, A. K., & Jamaludin, N. F. (2024). Sustainability practices of palm oil mills in the FELDA Sahabat region. In IOP Conference Series: Earth and Environmental Science (Vol. 1397, No. 1, p. 012019). IOP Publishing.

Angevin, F., Fortino, G., Bockstaller, C., Pelzer, E., & Messean, A. (2017). Assessing the sustainability of crop production systems: Toward a common framework?. Crop Protection, 97, 18-27.

Angilella, S., Catalfo, P., Corrente, S., Giarlotta, A., Greco, S., & Rizzo, M. (2018). Robust sustainable development assessment with composite indices aggregating interacting dimensions: The hierarchical-SMAA-Choquet integral approach. Knowledge-Based Systems, 158, 136-153.

Ansari, T. M., Marr, I. L., & Tariq, N. (2004). Heavy metals in marine pollution perspective-a mini review. Journal of Applied Sciences, 4(1), 1-20.

Antara, M., Lamusa, A., Laksmayani, M. K., Tangkesalu, D., & Imran, E. (2023). Income Diversity and Other Socioeconomic Factors That Influence the Household Food Security of Small-Scale Lowland Rice Farmers in Indonesia. International Journal of Sustainable Development & Planning, 18(3).

Anuar, K. F., Zainudin, N. M., & Fauzi, M. A. (2024). Developing and Validating an Assessment Instrument for Organizational Performances of Construction Organization. Journal of Advanced Research in Business and Management Studies, 35(1), 1-10.

Apostolopoulos, N., & Liargovas, P. (2016). Regional parameters and solar energy enterprises: Purposive sampling and group AHP approach. International Journal of Energy Sector Management, 10(1), 19-37.

Arimbawa, P., Limi, M. A., Sarinah, S., & Bahari, D. I. (2025). The role of opinion leaders in accelerating agricultural practices: strategies to increase farmers' capacity in organic rice cultivation. Tropical Agriculture, 102(3), 396-409.

Arushanyan, Y., Ekener, E., & Moberg, Å. (2017). Sustainability assessment framework for scenarios–SAFS. Environmental impact assessment review, 63, 23-34.

Astari, A. J., Somantri, L., Bratanegara, A. S., Ihsan, H. M., & Aliyan, S. A. (2022, November). Ecological criteria for sustainability in global, national, and local scales: a review of the literature and case study in the indonesian palm oil sector. In IOP Conference Series: Earth and Environmental Science (Vol. 1089, No. 1, p. 012072). IOP Publishing.

Awotide, B. A., Awoyemi, T. T., Diagne, A., Kinkingnihoun, F. M., & Ojehomone, V. (2012). Effect of income diversification on poverty reduction and income inequality in rural Nigeria: evidence from rice farming households. OIDA International Journal of Sustainable Development, 5(10), 65-78.

Azad, A., Sernbo, E., Svärd, V., Holmlund, L., & Björk Brämberg, E. (2021). Conducting in-depth interviews via mobile phone with persons with common mental disorders and multimorbidity: the challenges and advantages as experienced by participants and researchers. International Journal of Environmental Research and Public Health, 18(22), 11828.

Azri, N. S. binti A. ., Rahman, A. A. A., Yasid, A. F. M. ., Alias, M. S. bin ., & Hamid, N. F. A. . (2025). Literature Review on Malaysia National Food Security: Challenge And Strategy in Meeting Population Rise . Journal of Ecohumanism, 4(1), 1876 –. https://doi.org/10.62754/joe.v4i1.6006

Babcicky, P. (2013). Rethinking the foundations of sustainability measurement: the limitations of the Environmental Sustainability Index (ESI). Social Indicators Research, 113(1), 133-157.

Babu, S. S. (2024). Is Agricultural Production Responsible for Environmental Degradation in India? Implications for Sustainability Based on Panel Data Analysis. Global Journal of Emerging Market Economies, 16(3), 340-370.

Baffoe-Djan, J. B., & Smith, S. A. (2019). Descriptive statistics in data analysis. In The Routledge handbook of research methods in applied linguistics (pp. 398-414). Routledge.

Baig, M. F., Mustafa, M. R. U., Saputra, A., Shah, M. M., & Takaijudin, H. B. (2023). Assessment of hydrogeological parameters in a tropical region using GIS and AHP. In IOP Conference Series: Earth and Environmental Science (Vol. 1135, No. 1, p. 012022). IOP Publishing

Bakar, N. A. A., Bastami, M. S., Rahman, M. H. A., Rasdi, R. M., Rashid, M. A., Hashim, S., ... & Suptian, M. F. M. (2025). Life cycle greenhouse gas emission reduction potential of alternate wetting and drying in rice cultivation under Malaysian major granary areas. Journal of Cleaner Production, 521, 146212.

Bala, B. K., Alias, E. F., Arshad, F. M., Noh, K. M., & Hadi, A. H. A. (2014). Modelling of food security in Malaysia. Simulation Modelling Practice and Theory, 47, 152-164.

Banda, M. L. M., Mloza Banda, H. R., Kibirige, D., & Cornelis, W. (2025). Social-Ecological Attributes of Conservation Agriculture in Southern Malawi. South African Journal of Agricultural Extension, 53(3), 1-34.

Barbosa, M. W., & Cansino, J. M. (2022). A Water Footprint Management Construct in Agri-Food Supply Chains: A Content Validity Analysis. Sustainability, 14(9), 4928. https://doi.org/10.3390/su14094928.

Barrier, E. B. (2017). The concept of sustainable economic development. In The economics of sustainability (pp. 87-96). Routledge.

Bathaei, A., & Štreimikienė, D. (2023). A systematic review of agricultural sustainability indicators. Agriculture, 13(2), 241.

Bazeley, P., & Jackson, K. (2014). Qualitative data analysis with NVivo. Los Angeles, CA: Sage

Bell, S., & Morse, S. (2008). Sustainability Indicators: Measuring the Immeasurable? Earthscan. London. Sterling, VA.

Bell, S., & Morse, S. (2012). Sustainability indicators: measuring the immeasurable?. Routledge.

Ben-Eli, M.U., 2018. Sustainability: definition and five core principles, a systems perspec-tive. Sustain.Sci. 13, 1337–1343.https://doi.org/10.1007/s11625-018-0564-3

Benzaghta, M. A., Elwalda, A., Mousa, M. M., Erkan, I., & Rahman, M. (2021). SWOT analysis applications: An integrative literature review. Journal of Global Business Insights, 6(1), 55-73.

Bernard, H. R. (2002). Research methods in cultural anthropology: Qualitative and quantitative.

Bhaskaran, R., Hajela, A., & Dewan, A. (2024). Social sustainability of neighbourhood parks in India-instrument content validity. Brazilian Journal of Development, 10(10), e73386-e73386.

Biesta, G. (2010). Pragmatism and the philosophical foundations of mixed methods research. In Handbook of Mixed Methods in Social and Behavioral Research, 2nd ed. Edited by Abbas Tashakkori and Charles Teddlie. Thousand Oaks: Sage, pp. 95–117.

Binder, C. R., Feola, G., & Steinberger, J. K. (2010). Considering the normative, systemic and procedural dimensions in indicator-based sustainability assessments in agriculture. Environmental impact assessment review, 30(2), 71-81.

Bockstaller, C., Guichard, L., Keichinger, O., Girardin, P., Galan, M. B., & Gaillard, G. (2009). Comparison of methods to assess the sustainability of agricultural systems. A review. Agronomy for sustainable development, 29(1), 223-235.

Böhringer, C., & Jochem, P. E. (2007). Measuring the immeasurable—A survey of sustainability indices. Ecological economics, 63(1), 1-8.

Bond, A., Morrison-Saunders, A., & Pope, J. (2012). Sustainability assessment: the state of the art. Impact Assessment and Project Appraisal, 30(1), 53-62.

Bonny, B. P., & Vijayaragavan, K. (2001). Adoption of sustainable agricultural practices by traditional rice growers. Journal of Tropical Agriculture, 39(2), 151-156.

Bonny, B. P., Prasad, R. M., & Paulose, S. (2010). Agro-ecosystem Performance Index (API). A quantitative approach to evaluate the sustainability of rice production systems. Journal of Sustainable Agriculture, 34(7), 758-777.

Booysen, F. (2002). An overview and evaluation of composite indices of development. Social indicators research, 59(2), 115-151.

Bovey, R. (2009). Professional Excel development: The definitive guide to developing applications using Microsoft Excel, VBA, and. Net. Addison-Wesley Professional.

Brandi, C., Cabani, T., Hosang, C., Schirmbeck, S., Westermann, L., & Wiese, H. (2015). Sustainability standards for palm oil: challenges for smallholder certification under the RSPO. The Journal of Environment & Development, 24(3), 292-314.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative research in psychology, 3(2), 77-101.

Brennan, M., Hennessy, T., & Dillon, E. (2020). Towards a better measurement of the social sustainability of Irish agriculture. International Journal of Sustainable Development, 23(3-4), 263-287.

Brennan, M., Hennessy, T., Dillon, E., & Meredith, D. (2023). Putting social into agricultural sustainability: Integrating assessments of quality of life and wellbeing into farm sustainability indicators. Sociologia Ruralis, 63(3), 629-660.

Brundtland, G. H., & Khalid, M. (1987). Our common future. Oxford University Press, Oxford, GB.

Buang, A., & Suryandari, R. Y. (2017). Dasar Wawasan Negara dan prospek Pembangunan petani kecil Melayu (The Malaysian National Vision Policy and the advancement prospects of the Malay small-scale farmers). Geografia-Malaysian Journal of Society and Space, 7(2).

Buhr, L., Lenzi, D. S., Pols, A. J., Brunner, C. E., Fischer, A., Staal, A., ... & Bovenkerk, B. (2025). The concepts of irreversibility and reversibility in research on anthropogenic environmental changes. PNAS nexus, 4(1), pgae577.

Bujdei-Tebeica, V (2024). Green Policies, Gray Areas: Farmers' Protests and the Environmental Policy Dilemma in the European Union.

Byrne, D. (2022). A worked example of Braun and Clarke’s approach to reflexive thematic analysis. Quality & quantity, 56(3), 1391-1412.

Cacuci, D. G., & Ionescu-Bujor, M. (2004). A comparative review of sensitivity and uncertainty analysis of large-scale systems—II: statistical methods. Nuclear science and engineering, 147(3), 204-217.

Calafat-Marzal, C., Roig-Tierno, N., Cervera, F. J., Gallego-Salguero, Á., & García-Alvarez-Coque, J. M. (2026). Ensuring agriculture's future: How to foster generational renewal in semi-arid Mediterranean region. Cities, 168, 106422.

Campbell, S., Greenwood, M., Prior, S., Shearer, T., Walkem, K., Young, S., ... & Walker, K. (2020). Purposive sampling: complex or simple? Research case examples. Journal of research in Nursing, 25(8), 652-661

Carter, C. R., & Rogers, D. S. (2008). A framework of sustainable supply chain management: moving toward new theory. International journal of physical distribution & logistics management, 38(5), 360-387.

Castoldi, N., & Bechini, L. (2010). Integrated sustainability assessment of cropping systems with agroecological and economic indicators in northern Italy. European journal of agronomy, 32(1), 59-72.

Catanzaro, M. (1988). Using qualitative analytical techniques. Nursing research: Theory and practice, 437(456), 262.

Chalil, D., Barus, R., & Siddique, S. F. (2024). Does farmer’s institution matter for sustainable certification? case in Indonesia and Malaysian oil palm smallholders. In IOP Conference Series: Earth and Environmental Science (Vol. 1413, No. 1, p. 012103). IOP Publishing.

Chand, P., Sirohi, S., & Sirohi, S. K. (2015). Development and application of an integrated sustainability index for small-holder dairy farms in Rajasthan, India. Ecological Indicators, 56, 23-30.

Chang, S. H. E., Benjamin, E. O., & Sauer, J. (2024). Factors influencing the adoption of sustainable agricultural practices for rice cultivation in Southeast Asia: a review. Agronomy for Sustainable Development, 44(3), 27.

Change, C. (2022). Mitigating Climate Change. Working Group III contribution to the sixth assessment report of the intergovernmental panel on climate change.

Chen, J. (2007). Rapid urbanization in China: A real challenge to soil protection and food security. Catena, 69(1), 1-15.

Cho, J., & Trent, A. (2006). Validity in qualitative research revisited. Qualitative research, 6(3), 319-340.

Chofreh, A. G., & Goni, F. A. (2017). Review of frameworks for sustainability implementation. Sustainable Development, 25(3), 180-188.

Chofreh, A. G., Goni, F. A., & Klemeš, J. J. (2018). Evaluation of a framework for sustainable Enterprise Resource Planning systems implementation. Journal of cleaner production, 190, 778-786.

Chopin, P., Mubaya, C. P., Descheemaeker, K., Öborn, I., & Bergkvist, G. (2021). Avenues for improving farming sustainability assessment with upgraded tools, sustainability framing and indicators. A review. Agronomy for Sustainable Development, 41(2), 19.

Chowdhury, S., & Squire, L. (2006). Setting weights for aggregate indices: An application to the commitment to development index and human development index. The Journal of Development Studies, 42(5), 761-771.

Christo, B. F., Okawati, G. A. A., de Vasconcellos, D. M., Rosas, J. T. F., de Araujo, M. A., Dourado-Neto, D., & Nóia-Júnior, R. D. S. (2025). Agricultural sustainability index in Brazil. Environmental Challenges, 19, 101133.

Cinelli, M., Coles, S. R., & Kirwan, K. (2014). Analysis of the potentials of multi criteria decision analysis methods to conduct sustainability assessment. Ecological indicators, 46, 138-148.

Claasen, N., Covic, N. M., Idsardi, E. F., Sandham, L. A., Gildenhuys, A., & Lemke, S. (2015). Applying a transdisciplinary mixed methods research design to explore sustainable diets in rural South Africa. International Journal of Qualitative Methods, 14(2), 69-91.

Clapp, J., Moseley, W. G., Burlingame, B., & Termine, P. (2022). The case for a six-dimensional food security framework. Food policy, 106, 102164.

Costa, A. J., Curi, D., Bandeira, A. M., Ferreira, A., Tomé, B., Joaquim, C., ... & Marques, R. P. (2022). Literature review and theoretical framework of the evolution and interconnectedness of corporate sustainability constructs. Sustainability, 14(8), 4413.

Coupland, R. (2007). Security, insecurity and health. Bulletin of the World Health Organization, 85(3), 181-184.

Creswell, J. W. (1999). Mixed-method research: Introduction and application. In Handbook of educational policy (pp. 455-472). Academic press.

Dalati, S. (2018). Measurement and measurement scales. In Modernizing the Academic Teaching and Research Environment: Methodologies and Cases in Business Research (pp. 79-96). Cham: Springer International Publishing.

Dalsgaard, J. P. T., & Oficial, R. T. (1997). A quantitative approach for assessing the productive performance and ecological contributions of smallholder farms. Agricultural Systems, 55(4), 503-533.

Damanhuri, N. A., Harun, S. N., & Abd Rahim, S. (2024). Assessment of heavy metal contamination in paddy field soils: A case study in Ranau Valley, Sabah, Malaysia. In E3S Web of Conferences (Vol. 599, p. 03001). EDP Sciences.

Dantsis, T., Douma, C., Giourga, C., Loumou, A., & Polychronaki, E. A. (2010). A methodological approach to assess and compare the sustainability level of agricultural plant production systems. Ecological indicators, 10(2), 256-263.

Davis, L. L. (1992). Instrument review: Getting the most from a panel of experts. Applied nursing research, 5(4), 194-197..

De Luca, A. I., Falcone, G., Stillitano, T., Iofrida, N., Strano, A., & Gulisano, G. (2018). Evaluation of sustainable innovations in olive growing systems: A Life Cycle Sustainability Assessment case study in southern Italy. Journal of Cleaner Production, 171, 1187-1202.

De Olde, E. M., Moller, H., Marchand, F., McDowell, R. W., MacLeod, C. J., Sautier, M., ... & Manhire, J. (2017). When experts disagree: the need to rethink indicator selection for assessing sustainability of agriculture. Environment, Development and Sustainability, 19(4), 1327-1342.

De Olde, E. M., Oudshoorn, F. W., Sørensen, C. A., Bokkers, E. A., & De Boer, I. J. (2016). Assessing sustainability at farm-level: Lessons learned from a comparison of tools in practice. Ecological Indicators, 66, 391-404.

De Vos, R. E., Suwarno, A., Slingerland, M., Van Der Meer, P. J., & Lucey, J. M. (2021). Independent oil palm smallholder management practices and yields: can RSPO certification make a difference?. Environmental Research Letters, 16(6), 065015.

Defiesta, G., & Rapera, C. (2014). Measuring adaptive capacity of farmers to climate change and variability: Application of a composite index to an agricultural community in the Philippines. Journal of Environmental Science and Management, 17(2).

Delzeit, R., & Holm-Müller, K. (2009). Steps to discern sustainability criteria for a certification scheme of bioethanol in Brazil: Approach and difficulties. Energy, 34(5), 662-668.

Deng, T., & Mohamad, Z. F. (2026). Context-sensitive agricultural sustainability assessment: A systematic review of frameworks and local adaptation criteria. Agricultural Systems, 231, 104532.

Department of Agriculture Malaysia. (2022). Rice Check PADI (1st ed.). Jabatan Pertanian Malaysia.

Department of Agriculture Malaysia. (2023). myGAP certification guideline for the food crop subsector. Ministry of Agriculture and Food Security Malaysia

Department of Agriculture Malaysia. (2025). Booklet statistik tanaman (Sub-Sektor Tanaman Agromakanan): Statistik tanaman 2025.

Devkota, K. P., Beebout, S. E., & Bunquin, M. A. (2022). Setting sustainability targets for irrigated rice production and application of the Sustainable Rice Platform performance indicators. Environmental Impact Assessment Review, 92, 106697.

Dewan Negeri Selangor. (n.d.). Loji Pemprosesan Padi Benih Sungai Burong. Retrieved December 4, 2025, from https://dewan.selangor.gov.my/question/loji-pemprosesan-padi-benih-sungai-burong-2/

Diaz-Balteiro, L., González-Pachón, J., & Romero, C. (2017). Measuring systems sustainability with multi-criteria methods: A critical review. European Journal of Operational Research, 258(2), 607-616.

Dilipkumar, M., Ahmad-Hamdani, M. S., Rahim, H., Chuah, T. S., & Burgos, N. R. (2021). Survey on weedy rice (Oryza spp.) management practice and adoption of Clearfield® rice technology in Peninsular Malaysia. Weed Science, 69(5), 558-564.

Dillon, D. R., O'Brien, D. G., & Heilman, E. E. (2000). Literacy research in the next millennium: From paradigms to pragmatism and practicality. Reading Research Quarterly, 35(1), 10-26.

Dmuchowski, W., Baczewska-Dąbrowska, A. H., & Gworek, B. (2024). The role of temperate agroforestry in mitigating climate change: A review. Forest Policy and Economics, 159, 103136.

Dobbie, M. J., & Dail, D. (2013). Robustness and sensitivity of weighting and aggregation in constructing composite indices. Ecological Indicators, 29, 270-277.

Doetzer, J., Kaiser-Grolimund, A., Ammann, P., Imboden, M., Jeong, A., Veillat, A., ... & Probst, N. (2025). A call for research and policy into building multi-layered social resilience towards a sustainable agricultural workforce in Switzerland. Frontiers in Public Health, 13, 1617575.

Dogruyol, K., Aziz, Z., & Arayici, Y. (2018). Eye of sustainable planning: A conceptual heritage-led urban regeneration planning framework. Sustainability, 10(5), 1343.

Dong, F., Mitchell, P. D., Knuteson, D., Wyman, J., Bussan, A. J., & Conley, S. (2016). Assessing sustainability and improvements in US Midwestern soybean production systems using a PCA–DEA approach. Renewable Agriculture and Food Systems, 31(6), 524-539.

Doni, F., Isahak, A., Ghazali, R., Mohd Zain, C. R. C., Sulaiman, N., Siwar, C., & Wan Yusoff, W. M. (2016). Transforming the economy of small scale rice farmers in Malaysia via system of rice intensification (SRI). Ecology, Environment and Conservation, 22(3), 1151-1157.

Doni, F., Zain, C. R. C. M., Isahak, A., Fathurrahman, F., Sulaiman, N., Uphoff, N., & Yusoff, W. M. W. (2017). Relationships observed between Trichoderma inoculation and characteristics of rice grown under System of Rice

Intensification (SRI) vs. conventional methods of cultivation. Symbiosis, 72(1), 45-59.

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. Journal of business research, 133, 285-296.

Dorairaj, D., & Govender, N. T. (2023). Rice and paddy industry in Malaysia: Governance and policies, research trends, technology adoption and resilience. Frontiers in Sustainable Food Systems, 7, 1093605. https://doi.org/10.3389/fsufs.2023.1093605.

Dordkeshan, M. J., Shamsudin, M. N., Mohamed, Z., & Radam, A. (2017). Assessing the impact of rice import quota policy on the Malaysian rice sector. Journal of Food Products Marketing, 23(8), 890-900.

Dumanski, J., & Pieri, C. (1996). Application of the pressure-state-response framework for the land quality indicators (LQI) programme. FAO.

Durand-Morat, A., & Bairagi, S. (2021). International rice outlook: international rice baseline projections 2020-2030.

Ehigiamusoe, K. U., Lean, H. H., & Somasundram, S. (2024). Analysis of the environmental impacts of the agricultural, industrial, and financial sectors in Malaysia. Energy & Environment, 35(5), 2329-2356.

Eichler Inwood, S. E., López-Ridaura, S., Kline, K. L., Gérard, B., Monsalue, A. G., Govaerts, B., & Dale, V. H. (2018). Assessing sustainability in agricultural landscapes: A review of approaches1, 2. Environmental Reviews, 26(3), 299-315.

Ekawati, Rizieq, R., Ellyta, Bancin, H. D., Aini, F., & Satria, R. (2025). Sustainability index of new improved rice varieties adoption: an ecological perspective. In IOP Conference Series: Earth and Environmental Science (Vol. 1535, No. 1, p. 012018). IOP Publishing.

Elbarkouky, M. G., Ezzeldin, A. S., & Elassaly, A. (2012). A multi-criteria decision-making (MCDM) framework for prioritizing damaged infrastructure and services facilities in Egypt using sustainability objectives. In Annual Conference of the Canadian Society for Civil Engineering: Leadership in Sustainable Infrastructure (pp. 6-9).

Ellis, W., Lomax, J., & Bouman, B. (2014). Role of voluntary sustainability standards in South–South food commodity supply chains: the case of the sustainable rice platform. Voluntary standards for sustainable food systems: challenges and opportunities, 187.

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. Journal of advanced nursing, 62(1), 107-115.

Er, A. C., Ahmad, H., & Manaf, A. A. (2021). Comparative cost benefit analysis of conventional farming and agroecological farming for paddy cultivation in Bachok, Kelantan. Int. J. Environ. Sci. Develop, 12, 181-187

Erlingsson, C., & Brysiewicz, P. (2017). A hands-on guide to doing content analysis. African journal of emergency medicine, 7(3), 93-99.

Escalada, M. M., & Heong, K. L. (1997). Methods for research on farmers' knowledge, attitudes, and practices in pest management. Pest management of rice farmers in Asia, 1-34.

Etikan, I., & Bala, K. (2017). Sampling and sampling methods. Biometrics & Biostatistics International Journal, 5(6), 00149.

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. American journal of theoretical and applied statistics, 5(1), 1-4.

Evans, D., & Kowanko, I. (2001). Literature reviews: Evolution of a research methodology. Australian Journal of Advanced Nursing, 18(2).Murphy, K. (2012). The social pillar of sustainable development: a literature review and framework for policy analysis. Sustainability: Science, practice and policy, 8(1), 15-29.

Ewert, F., van Ittersum, M. K., Heckelei, T., Therond, O., Bezlepkina, I., & Andersen, E. (2011). Scale changes and model linking methods for integrated assessment of agri-environmental systems. Agriculture, Ecosystems & Environment, 142(1-2), 6-17.

Fagerberg, J. (2001). Europe at the crossroads: The challenge from innovation-based growth in the Globalising Learning Economy, B. Lundvall and D. Archibugi eds.

Fahad, S., Nie, L., Hussain, S., Khan, F., Khan, F. A., Saud, S., ... & Huang, J. (2015). Rice pest management and biological control. In Sustainable agriculture reviews: cereals (pp. 85-106). Cham: Springer International Publishing.

Fajardo-Gonzalez, J., Lovell, C. K., Lovell, J., & Edmonds, H. (2025). Measuring climate risks: A new multidimensional index for global vulnerability and resilience. Environmental Development, 56, 101227.

Fauzi, N. F. B., Ahmad, F., & Gelaidan, H. M. (2013). The employee retention status in paddy and rice industry in Malaysia. World Applied Sciences Journal, 25(4), 644-652.

Ferrari, R. (2015). Writing narrative style literature reviews. Medical writing, 24(4), 230-235.

Fiksel, J. (2006). Sustainability and resilience: toward a systems approach. Sustainability: Science, Practice and Policy, 2(2), 14-21.

Firdaus, R. B. R., Ibrahim, A. Z., Siwar, C., & Jaafar, A. H. (2014). The livelihood of paddy farmers in facing challenges of climatic change: The role of government intervention through paddy price subsidy scheme. Kajian Malaysia, 32(2), 73-92.

Firdaus, R. R., Leong Tan, M., Rahmat, S. R., & Senevi Gunaratne, M. (2020). Paddy, rice and food security in Malaysia: A review of climate change impacts. Cogent Social Sciences, 6(1), 1818373.

Firouzjaie, A. A., Sadighi, H., & Mohammadi, M. A. (2007). The influence of social capital on adoption of rural development programs by farmers in the caspian sea region of Iran. Am. J. Agric. Bio. Sci, 2, 15-22.

Flick, U. (2018). An introduction to qualitative research. Sage.

Floress, K., Reimer, A., Thompson, A., Burbach, M., Knutson, C., Prokopy, L., ... & Ulrich-Schad, J. (2018). Measuring farmer conservation behaviors: Challenges and best practices. Land use policy, 70, 414-418.

Folberth, C., Sinabell, F., Schinko, T., Hanger-Kopp, S., Lappöhn, S., Mitter, H., ... & Süssenbacher, E. (2025). Integrating global comparability and national specificity in agricultural sustainability indicators through stakeholder-science co-evaluation in Austria. Community Science, 4(1), e2024CSJ000092.

Food and Agriculture Organization of the United Nations. (2014). SAFA: Sustainability Assessment of Food and Agriculture Systems: Guidelines (Version 3.0). FAO.

Food and Agriculture Organization of the United Nations. (2026). FAO Food Price Index up for third consecutive month largely on rising vegetable oil prices. FAO Newsroom. Retrieved May 12, 2026, from https://www.fao.org/newsroom/detail/fao-food-price-index-up-for-third-consecutive-month-largely-on-rising-vegetable-oil-prices/en

Forney, J., Bentia, D., & Dwiartama, A. (2025). Everyday Agri-Environmental Governance: The Emergence of Sustainability through Assemblage Thinking (p. 159). Taylor & Francis.

Franks, J., & Frater, P. (2013). Measuring agricultural sustainability at the farm-level: A pragmatic approach. International Journal of Agricultural Management, 2(4), 207-225.

Fredericks, S. (2013). Measuring and evaluating sustainability: Ethics in sustainability indexes. Routledge.

Fuad, M. M., Junaidi, A. B., Habibah, A., Hamzah, J., Toriman, M. E., Lyndon, N., ... & Azima, A. M. (2012). The impact of pesticides on paddy farmers and the ecosystem. Advances in Natural and Applied Sciences, 6(1), 65-70.

Fuglie, K. O., King, J. L., Heisey, P. W., & Schimmelpfennig, D. E. (2012). Rising concentration in agricultural input industries influences new farm technologies. Amber Waves: The Economics of Food, Farming, Natural Resources, and Rural America, (4).

Gabriel de Pinna Mendez, Claudio Fernando Mahler, & Stella Regina Taquette. (2021). Qualitative Research in a Period of Social Detachment: The Challenge of Conducting Remote Interviews. New Trends in Qualitative Research, 9, 336–343. https://doi.org/10.36367/ntqr.9.2021.336-343

Galanakis, C. M., Daskalakis, M. I., Galanakis, I., Gallo, A., Marino, E. A. E., Chalkidou, A., & Agrafioti, E. (2025). A systematic framework for understanding food security drivers and their interactions. Discover Food, 5(1), 178.

Gan, X., Fernandez, I. C., Guo, J., Wilson, M., Zhao, Y., Zhou, B., & Wu, J. (2017). When to use what: Methods for weighting and aggregating sustainability indicators. Ecological indicators, 81, 491-502.

Garcia, G. S., Craveiro, C., Rocha, C., & Recine, E. (2025). Concepts, Methods, and Parameters: A Scoping Review of Tools for Assessing Food System Sustainability. Environmental and Sustainability Indicators, 100782.

Garcia-Bernabeu, A., Cabello, J. M., & Ruiz, F. (2022). A reference point-based proposal to build regional quality of life composite indicators. Social Indicators Research, 164(1), 11-30.

Gennari, P., & Navarro, D. K. (2019). The challenge of measuring agricultural sustainability in all its dimensions. Journal of Sustainability Research, 1(2).

Georgeson, L., Maslin, M., & Poessinouw, M. (2017). The global green economy: a review of concepts, definitions, measurement methodologies and their interactions. Geo: Geography and Environment, 4(1), e00036.

Gharsallah, O., Gandolfi, C., & Facchi, A. (2021). Methodologies for the sustainability assessment of agricultural production systems, with a focus on rice: a review. Sustainability, 13(19), 11123.

Giacobbi, P. R., Poczwardowski, A., & Hager, P. (2005). A pragmatic research philosophy for sport and exercise psychology. The sport psychologist, 19(1), 18-31.

Glavič, P., & Lukman, R. (2007). Review of sustainability terms and their definitions. Journal of cleaner production, 15(18), 1875-1885.

Godfrey, L., & Todd, C. (2001). Defining thresholds for freshwater sustainability indicators within the context of South African water resource management. Practice, Cases. Cape Town, South Africa.

Goldschmidt, K., Harrison, T., Holtry, M., & Reeh, J. (2013). Sustainable procurement: integrating classroom learning with university sustainability programs. Decision Sciences Journal of Innovative Education, 11(3), 279-294.

Goles, T., & Hirschheim, R. (2000). The paradigm is dead, the paradigm is dead… long live the paradigm: the legacy of Burrell and Morgan. Omega, 28(3), 249-268.

Gombkötő, N., Vinkóczi, T., & Koltai, J. P. (2025). Estimating agricultural sustainability: a multidimensional approach to a farm-level assessment tool. Frontiers in Environmental Science, 13, 1704344.

Gómez-Limón, J. A., & Sanchez-Fernandez, G. (2010). Empirical evaluation of agricultural sustainability using composite indicators. Ecological economics, 69(5), 1062-1075.

Gowda, M. C., & Jayaramaiah, K. M. (1998). Comparative evaluation of rice production systems for their sustainability. Agriculture, Ecosystems & Environment, 69(1), 1-9.

Graymore, M. L., Sipe, N. G., & Rickson, R. E. (2008). Regional sustainability: How useful are current tools of sustainability assessment at the regional scale?. Ecological economics, 67(3), 362-372.

Greckhamer, T., & Cilesiz, S. (2014). Rigor, transparency, evidence, and representation in discourse analysis: Challenges and recommendations. International journal of qualitative methods, 13(1), 422-443.

Greco, S., Ishizaka, A., Tasiou, M., & Torrisi, G. (2019). On the methodological framework of composite indices: A review of the issues of weighting, aggregation, and robustness. Social indicators research, 141(1), 61-94.

Grontkowska, A., Golebiewska, B., & Gebska, M. (2020). The concept of sustainable agriculture evaluated by agricultural producers depending on farm income. Annals of the Polish Association of Agricultural and Agribusiness Economists, 22(4).

Gunnarsdóttir, I., Davíðsdóttir, B., Worrell, E., & Sigurgeirsdottir, S. (2021). It is best to ask: Designing a stakeholder-centric approach to selecting sustainable energy development indicators. Energy Research & Social Science, 74, 101968.

Guo, X., Wang, C., & Zhang, F. (2022). Construction of an index system for sustainability assessment in smallholder farming systems. Engineering Agriculture, 9(4), 511.

Gürel, E., & Tat, M. (2017). SWOT analysis: A theoretical review. Journal of International Social Research, 10(51), 994-1006.

Gutiérrez, E. V. G., Flórez, M. F., Mazo, J. S., Pacheco, S. M., Aristizábal, M. C., & Cardenas, L. M. (2022). Characterization of methodologies for the integrated assessment of urban transportation sustainability. Ingeniería y universidad, 26, 3.

Hakimi, F., & Hamdoun, F. Z. (2023). A multi-criteria sustainability assessment of mediterranean rainfed farming systems using the IDEA method: A moroccan case study. Caraka Tani: Journal of Sustainable Agriculture, 38(2), 339-358.

Hamat, Z. (2014). Zakat assessment for agricultural in Malaysia: rules, fatawa, and practices. Journal of Educational and Social Research, 4(2), 110-116.

Hanafiah, M. M., Ghazali, N. F., Harun, S. N., Abdulaali, H. S., AbdulHasan, M. J., & Kamarudin, M. K. A. (2019). Assessing water scarcity in Malaysia: a case study of rice production. Desalination and water Treatment, 149, 274-287.

Häni, F., Braga, F., Stämpfli, A., Keller, T., Fischer, M., & Porsche, H. (2003). RISE, a tool for holistic sustainability assessment at the farm level. International food and agribusiness management review, 6(4), 78-90.

Hansen, J. W. (1996). Is agricultural sustainability a useful concept?. Agricultural systems, 50(2), 117-143.

Harger, J. R. E., & Meyer, F. M. (1996). Definition of indicators for environmentally sustainable development. Chemosphere, 33(9), 1749-1775.

Haris, N. B. M. (2013). Influence of Decision-making Factors on Paddy Production of Farmers in Selected Integrated Agriculture Development Areas, Malaysia (Doctoral dissertation, Universiti Putra Malaysia).

Harun, S. N., Hanafiah, M. M., & Aziz, N. I. H. A. (2021). An LCA-based environmental performance of rice production for developing a sustainable agri-food system in Malaysia. Environmental management, 67(1), 146-161.

Harun, S. N., Hanafiah, M. M., & Noor, N. M. (2022). Rice straw utilisation for bioenergy production: A brief overview. Energies, 15(15), 5542.

Hasan-Basri, B., Zabri, A. F., & Hasan, J. (2024). The Health Effects of Agricultural Pesticides: Are Farmers Willing to Pay. Jurnal Ekonomi Malaysia, 58(2), 1-12.

Haw, C. L., Ismail, W. I. W., Kairunniza-Bejo, S., Putih, A., & Shamshiri, R. (2014). Colour vision to determine paddy maturity. International Journal of Agricultural and Biological Engineering, 7(5), 55-63.

Hayati, D. (2017). A literature review on frameworks and methods for measuring and monitoring sustainable agriculture. Rome: Food and Agriculture Organization of the United Nations.

Hayati, D., Karami, E., & Slee, B. (2006). Combining qualitative and quantitative methods in the measurement of rural poverty: the case of Iran. Social indicators research, 75(3), 361-394.

Hayati, D., Ranjbar, Z., & Karami, E. (2010). Measuring agricultural sustainability. Biodiversity, biofuels, agroforestry and conservation agriculture, 73-100.

Hazra, K. K., Swain, D. K., Bohra, A., Singh, S. S., Kumar, N., & Nath, C. P. (2018). Organic rice: Potential production strategies, challenges and prospects. Organic agriculture, 8(1), 39-56.

Herman, E. (2024). Sustainable agriculture and its impact on the rural development in EU countries: A multivariate analysis. Land, 13(7), 947.

Herrera Sabillon, B., Gerster-Bentaya, M., & Knierim, A. (2022). Measuring farmers' well-being: Influence of farm-level factors on satisfaction with work and quality of life. Journal of agricultural economics, 73(2), 452-471.

Heydari, M., & Osanloo, M. (2024). Untangling the complex web of environmental, social, and economic impacts in deep and large-scale open-pit mining projects using a dynamic modeling framework. Resources Policy, 90, 104690.

Ho, T. D., Tsusaka, T. W., Kuwornu, J. K., Lam, L. M., & Vu, T. T. (2024). Does livelihood capital influence the livelihood diversification strategies of smallholder rice farmers? Evidence from the Mekong Delta of Vietnam. Cogent Economics & Finance, 12(1), 2397456.

Ibáñez-Forés, V., Bovea, M. D., & Pérez-Belis, V. (2014). A holistic review of applied methodologies for assessing and selecting the optimal technological alternative from a sustainability perspective. Journal of Cleaner Production, 70, 259-281.

Ibiyemi, A., Mohd Adnan, Y., Daud, M. N., Olanrele, S., & Jogunola, A. (2019). A content validity study of the test of valuers' support for capturing sustainability in the valuation process in Nigeria. Pacific Rim Property Research Journal, 25(3), 177-193.

Ibrahim, M., Krishna, B. K., & Fraser, E. D. (2025). Bridging the gap in sustainability measurement and reporting for agroecosystems: Overview and development of an adaptive sustainability assessment and monitoring framework. Ecological Indicators, 170, 113091.

Ikerd, J. (1993). Two related but distinctly different concepts: organic farming and sustainable agriculture. Small Farm Today 101.

Ilahi, W. F. F., Hassan, N. H. A., Che'Ya, N. N., Ismail, M. R., Berahim, Z., Zakaria, N. I., & Omar, M. H. (2022). Alternate Wetting and Drying (AWD) on Rice Irrigation. Pertanika Journal of Tropical Agricultural Science, 45(3).

Illahi, U., & Mir, M. S. (2020). Development of indices for sustainability of transportation systems: A review of state-of-the-art. Ecological Indicators, 118, 106760.

Intan Salassa, D., Dwi Prasetyo, G., & Rizki Noor Syafira, S. (2025). Analysis of rice cultivation sustainability in rice production centre areas, Indonesia. In BIO Web of Conferences (Vol. 175, p. 02005). EDP Sciences.

Iqbal, A., He, L., Ali, I., Ullah, S., Khan, A., Akhtar, K., ... & Jiang, L. (2021). Co-incorporation of manure and inorganic fertilizer improves leaf physiological traits, rice production and soil functionality in a paddy field. Scientific Reports, 11(1), 10048.

Iqbal, A., He, L., Khan, A., Wei, S., Akhtar, K., Ali, I., ... & Jiang, L. (2019). Organic manure coupled with inorganic fertilizer: An approach for the sustainable production of rice by improving soil properties and nitrogen use efficiency. Agronomy, 9(10), 651.

Ishak, A. M., Ahmad, A., Abdullah, N. A., Abdul Karim, U. A., Mohammad Husni, M. M., Lau, J., & Nor, N. M. (2022). Development of the National Water Balance Management System (NAWABS) for the Perak, Kurau and Kerian River Basins. In Proceedings of the 5th International Conference on Water Resources (ICWR)–Volume 1: Current Research in Water Resources, Coastal and Environment (pp. 137-148). Singapore: Springer Nature Singapore.

Ishak, N. A., & Rasiah, R. (2026). Agriculture, Food Security and Sustainability in Malaysia. In Sustainable Agriculture and Food Security in Southeast Asia: Towards Climate Resilience and Digitalization (pp. 49-67). Singapore: Springer Nature Singapore.

Jafari, Y., Othman, J., & Kuhn, A. (2017). Market and welfare impacts of agri-environmental policy options in the Malaysian rice sector. Malaysian Journal of Economic Studies, 54(2), 179-201.

Jamaludin, N. F., Hashim, H., Ab Muis, Z., Zakaria, Z. Y., Jusoh, M., Yunus, A., & Murad, S. M. A. (2018). A sustainability performance assessment framework for palm oil mills. Journal of Cleaner Production, 174, 1679-1693.

Jane Dillon, E., Hennessy, T., Buckley, C., Donnellan, T., Hanrahan, K., Moran, B., & Ryan, M. (2016). Measuring progress in agricultural sustainability to support policy-making. International Journal of Agricultural Sustainability, 14(1), 31-44.

Janjua, S. Y., Sarker, P. K., & Biswas, W. K. (2020). Development of triple bottom line indicators for life cycle sustainability assessment of residential bulidings. Journal of environmental management, 264, 110476.

Janker, J., Mann, S., & Rist, S. (2019). Social sustainability in agriculture–A system-based framework. Journal of rural studies, 65, 32-42.

Janova, J., Hampel, D., & Nerudova, D. (2019). Design and validation of a tax sustainability index. European Journal of Operational Research, 278(3), 916-926.

Jayachandran, S. (2015). The roots of gender inequality in developing countries. Annual review of economics, 7(1), 63-88.

Jayarathna, C. P., Agdas, D., Dawes, L., & Miska, M. (2022). Exploring sector-specific sustainability indicators: A content analysis of sustainability reports in the logistics sector. European Business Review, 34(3), 321-343.

Jayasiri, M. M. J. G. C. N., Dayawansa, N. D. K., Ingold, K., & Yadav, S. (2024). Are rice systems sustainable in Sri Lanka?-A case of Deduru Oya reservoir irrigation scheme. Environmental Impact Assessment Review, 106, 107503.

Jensenius, F. R., Htun, M., Samuels, D. J., Singer, D. A., Lawrence, A., & Chwe, M. (2018). The benefits and pitfalls of Google Scholar. PS: Political Science & Politics, 51(4), 820-824.

Jiabin, H. A. N., Shuyun, L. I. U., Shufeng, Z. H. A. N. G., & Yufeng, L. I. U. (2019). Influence of aging of agricultural labor force on large-scale management of land. Resources Science, 41(12), 2284-2295.

Johnson, R. B., & Christensen, L. (2014). Educational research: Quantitative, qualitative, and mixed approaches. Sage publications.

Joint Research Centre. (2008). Handbook on constructing composite indicators: methodology and user guide. OECD publishing.

Juntunen, M., & Lehenkari, M. (2021). A narrative literature review process for an academic business research thesis. Studies in higher education, 46(2), 330-342.

Juwana, I., Muttil, N., & Perera, B. J. C. (2012). Indicator-based water sustainability assessment—A review. Science of the total environment, 438, 357-371.

Kajikawa, Y., Inoue, T., & Goh, T. N. (2011). Analysis of building environment assessment frameworks and their implications for sustainability indicators.

Kalisz, B., Żuk-Gołaszewska, K., Radawiec, W., & Gołaszewski, J. (2023). Land use indicators in the context of land use efficiency. Sustainability, 15(2), 1106.

Kallio, H., Pietilä, A. M., Johnson, M., & Kangasniemi, M. (2016). Systematic methodological review: developing a framework for a qualitative semi-structured interview guide. Journal of advanced nursing, 72(12), 2954-2965.

Kalyana Sundram, L., & Matthew, N. K. (2025). Klang consumer's willingness to pay (WTP) for Malaysian good agricultural practices (myGAP) certified vegetables. SAGE Open, 15(1), 21582440251318487.

Kamaruddin, R., & Abd. Rashid, N. N. (2025). Sustainable farming management: key factors and impact on paddy yields in Malaysia's granary areas. Agriculture & Food Security, 14(1), 4.

Kamaruddin, R., & Rashid, N. N. A. (2023). The Impact Of Sustainable Farm Management On Paddy Farmers'livelihood: The Case Of Malaysia. In Annual Ecofi Symposium (Aes 2023) (P. 44).

Kamarudin, H., Adnan, N. A., & Mispan, M. R. (2016). Spatial variability of soil nutrient in paddy plantation: Sites FELCRA Seberang Perak. In IOP Conference Series: Earth and Environmental Science (Vol. 37, No. 1, p. 012047). IOP Publishing.

Kamyab, H., SaberiKamarposhti, M., Hashim, H., & Yusuf, M. (2024). Carbon dynamics in agricultural greenhouse gas emissions and removals: a comprehensive review. Carbon Letters, 34(1), 265-289.

Kandasamy, A., Chandrasekaran, K., Divakarla, U., & Krishna, M. (2025). Blockchain-Based Paddy Crop Marketplace: Enhancing Farmer-Buyer Trust Through Smart Contracts. MMFood'25, 11.

Karami, S., Karami, E., Buys, L., & Drogemuller, R. (2017). System dynamic simulation: a new method in social impact assessment (SIA). Environmental Impact Assessment Review, 62, 25-34.

Kashyap, S., Singh, V. P., Guru, S. K., Pratap, T., Singh, S. P., & Kumar, R. (2022). Effect of Integrated Weed Management on Weed and Yield of Direct Seeded Rice. Indian Journal of Agricultural Research, 56(1).

Kasim, S. N. S. A., Abas, M. A., & Chindo, S. (2023). Balancing the scales: Achieving food security and environmental sustainability in Malaysia through integrated approaches and collaborative governance. In BIO Web of Conferences (Vol. 73, p. 03003). EDP Sciences.

Kaushik, V., & Walsh, C. A. (2019). Pragmatism as a research paradigm and its implications for social work research. Social sciences, 8(9), 255.

Kelly, E., Latruffe, L., Desjeux, Y., Ryan, M., Uthes, S., Diazabakana, A., ... & Finn, J. (2018). Sustainability indicators for improved assessment of the effects of agricultural policy across the EU: Is FADN the answer?. Ecological indicators, 89, 903-911.

Kelly, L. M., & Cordeiro, M. (2020). Three principles of pragmatism for research on organizational processes. Methodological innovations, 13(2), 2059799120937242.

Kennedy P. (2003), A guide to Econometrics, 5th edition, MIT Press.

Keyvanfar, A. L. I., Shafaghat, A., Inn, T. S., & Mohamad, S. (2020). A Sustainable Urban Farming Index Assessment Model For Evaluating Food Productivity That Applies Multi-Criteria Decision-Making Methods—A Case Study In Malaysia. Journal of Sustainability Science and Management, 15(7), 123-146.

Khoo, G. S., & Yunus, A. (2026). Malaysia's rice self-sufficiency level stagnant at 52%, says Mat Sabu. The Star. Retrieved from https://www.thestar.com.my/news/nation/2026/02/05/malaysia039s-rice-self-sufficiency-level-stagnant-at-52-says-mat-sabu.

Khoo, K. O., Wongwai, K., & Wong, K. K. S. (2025). A comprehensive analysis of factors affecting paddy production in Malaysia. Malaysian Journal of Agricultural Economics, 32(1), a0000615. https://doi.org/10.36877/mjae.a0000615.

Khorramnia, K., Shariff, A. R. M., Rahim, A. A., & Mansor, S. (2014). Toward malaysian sustainable agriculture in 21st century. In IOP Conference Series: Earth and Environmental Science (Vol. 18, No. 1, p. 012142). IOP Publishing.

Kormos, C., & Gifford, R. (2014). The validity of self-report measures of proenvironmental behavior: A meta-analytic review. Journal of Environmental Psychology, 40, 359-371.

Krajnc, D., & Glavič, P. (2005). A model for integrated assessment of sustainable development. Resources, conservation and recycling, 43(2), 189-208

Krejcie, R. V., & Morgan, D. W. (1970). Sample size determination table. Educational and psychological Measurement, 30(3), 607-610.

Kumar, M., Bethapudi, S. V., & Gawali, S. (2025). Information Communication Technology Enables Agricultural Innovation and Sustainable Growth of Agripreneurs. Emerging Trends in Food and Agribusiness Marketing, 101-122.

Kumar, S., Chandra, S., Singh, D. R., & Chaudhary, K. R. (2013). Contractual arrangements and enforcement in India: The case of organic basmati paddy farming. Indian Journal of Agricultural Economics, 68(3), 449-456.

Kumaran, S. (2019). The dynamics for mandatory MSPO certification scheme to be successfully implemented. Journal of Oil Palm, Environment & Health, 10(148), 1-7.

Kumari, A., Tiwari, M., Mor, R., & Jagtap, S. (2025). Mapping research frontiers in gender and sustainability in agricultural development: a bibliometric review. Discover Sustainability, 6(1), 174.

Kurka, T., & Blackwood, D. (2013). Participatory selection of sustainability criteria and indicators for bioenergy developments. Renewable and sustainable energy reviews, 24, 92-102.

Kustova, I., Hudenko, J., & Lace, N. (2024). A systematic review of sustainability criteria in infrastructure development. Sustainability, 16(11), 4564.

Kwatra, S., Kumar, A., & Sharma, P. (2020). A critical review of studies related to construction and computation of Sustainable Development Indices. Ecological Indicators, 112, 106061.

Kyire, S. K. C., Kuwornu, J. K., Bannor, R. K., Apiors, E. K., & Martey, E. (2023). Perceived risk and risk management strategies under irrigated rice farming: Evidence from Tono and Vea irrigation schemes-Northern Ghana. Journal of Agriculture and Food Research, 12, 100593.

Kyle, P., Ollenburger, M., Zhang, X., Niazi, H., Durga, S., & Ou, Y. (2023). Assessing Multi-Dimensional Impacts of Achieving Sustainability Goals by Projecting the Sustainable Agriculture Matrix Into the Future. Earth's Future, 11(10), e2022EF003323.

Labansing, S. A., Sulong, R. S., & Idris, S. (2021). Sustainable certification in the Malaysian palm oil industry. Asian J. Res. Bus. Manag, 3, 119-131.

Land, K. C. (2006). The foundation for child development child and youth well-being index (CWI), 1975–2004, with projections for 2005. Duke University Durham, NC.

Landert, J., Pfeifer, C., Carolus, J., Schwarz, G., Albanito, F., Muller, A., ... & Miller, D. (2020). Assessing agro-ecological practices using a combination of three sustainability assessment tools. Landbauforschung, 70(2), 129-144.

Latruffe, L., Diazabakana, A., Bockstaller, C., Desjeux, Y., Finn, J., Kelly, E., ... & Uthes, S. (2016). Measurement of sustainability in agriculture: a review of indicators. Studies in Agricultural Economics, 118(3), 123-130.

Lawrence, D., & Vandecar, K. (2015). Effects of tropical deforestation on climate and agriculture. Nature climate change, 5(1), 27-36.

Lemence, A. L. G., & McLellan, B. C. (2024). Social Sustainability Assessment of Energy Systems: Research Status and Opportunities. In 2024 8th International Conference on Green Energy and Applications (ICGEA) (pp. 223-228). IEEE.

Lewis, J. L., & Sheppard, S. R. (2006). Culture and communication: Can landscape visualization improve forest management consultation with indigenous communities?. Landscape and urban planning, 77(3), 291-313.

Li, M., Fu, Q., Singh, V. P., Liu, D., Li, T., & Li, J. (2020). Sustainable management of land, water, and fertilizer for rice production considering footprint family assessment in a random environment. Journal of Cleaner Production, 258, 120785.

Liao, R., Chen, Z., Sirisrisakulchai, J., & Liu, J. (2025). Enhancing rural economic sustainability in China through agricultural socialization services: a novel perspective on spatial-temporal dynamics. Agriculture, 15(3), 267.

Libório, M. P., da Silva, L. M. L., Ekel, P. I., Figueiredo, L. R., & Bernardes, P. (2022). Consensus-based sub-indicator weighting approach: constructing composite indicators compatible with expert opinion. Social Indicators Research, 164(3), 1073-1099.

Libório, M. P., Ekel, P., Martínez, L., & Rabiei, H. (2025). Constructing composite indicators through extreme values reductions-ordered weighted averaging: human development index. IEEE Access.

Lim, S. M. A., & Ahad, A. D. (2014). Convenience or nuisance?: The “WhatsApp” dilemma. https://doi.org/10.1016/j.sbspro.2014.10.278

Limi, M. A., Fyka, S. A., Taridala, S. A. A., & Dewi, H. S. (2022). The relationship of the participation of rice farmers in managing water resources to rice production during the Covid 19 pandemic. In IOP Conference Series: Earth and Environmental Science (Vol. 1107, No. 1, p. 012071). IOP Publishing.

Lister, R. (2021). Poverty. John Wiley & Sons.

Liverman, D. M., Hanson, M. E., Brown, B. J., & Merideth Jr, R. W. (1988). Global sustainability: toward measurement. Environmental management, 12(2), 133-143.

Loh, J., Green, R.E., Ricketts, T., Lamoreux, J., Jenkins, M., Kapos, V., Randers, J., 2005. The Living Planet Index: using species population time series to track trends in biodiversity. Phil. Trans. R. Soc. B : Biol. Sci. 360 (1454), 289–295.

López-Ridaura, S., Keulen, H. V., Ittersum, M. V., & Leffelaar, P. A. (2005). Multiscale methodological framework to derive criteria and indicators for sustainability evaluation of peasant natural resource management systems. Environment, development and sustainability, 7(1), 51-69.

Luborsky, M. R., & Rubinstein, R. L. (1995). Sampling in qualitative research: Rationale, issues, and methods. Research on aging, 17(1), 89-113.

MacRae, R. J., Hill, S. B., Henning, J., & Mehuys, G. R. (1989). Agricultural science and sustainable agriculture: a review of the existing scientific barriers to sustainable food production and potential solutions. Biological agriculture & horticulture, 6(3), 173-219..

Magrini, A., & Giambona, F. (2022). A Composite Indicator to Assess Sustainability of Agriculture in European Union Countries: A. Magrini, F. Giambona. Social Indicators Research, 163(3), 1003-1036.

Mairghany, M., Adam, N. M., & Elsoragaby, S. (2022). Effect of Land Preparation, Water Management Practices and Planting Operation on Planting Quality in Rice Production.

Majlis Keselamatan Negara. (2022). MKN perkenal Indeks Keselamatan Kebangsaan hujung tahun ini. Retrieved May 12, 2026, from https://ikk.gov.my/mkn-perkenal-indeks-keselamatan-kebangsaan-hujung-tahun-ini/

Makhtar, S., Abidin, I. S. Z., & Islam, R. (2022). The impact of rice productivity in Malaysia: Econometric analysis. International Journal of Business and Economy, 4(3), 21-32.

Malak-Rawlikowska, A., Gębska, M., Hoste, R., Leeb, C., Montanari, C., Wallace, M., & de Roest, K. (2021). Developing a Methodology for Aggregated Assessment of the Economic Sustainability of Pig Farms. Energies, 14(6), 1760. https://doi.org/10.3390/en14061760

Malaysian Palm Oil Certification Council (MPOCC). (2023). Guidance document for MS2530-2-2:2022: Malaysian sustainable palm oil (MSPO) – General principles for organised smallholders (less than 40.46 hectares) (Version 1.0)

Maleksaeidi, H., Karami, E., & Zamani, G. H. (2015). Farm households' resilience scale under water scarcity. Mitigation and adaptation strategies for global change, 20(8), 1305-1318.

Manjhi, R. P., Meeta, K., & Satish, K. P. (2025). Efficacy of integrated weed management (IWM) practices on the weed dynamics, production and productivity of direct-seeded rice.

Marchand, F., Debruyne, L., Triste, L., Gerrard, C., Padel, S., & Lauwers, L. (2014). Key characteristics for tool choice in indicator-based sustainability assessment at farm level. Ecology and Society, 19(3).

Martin, S., Rieple, A., Chang, J., Boniface, B., & Ahmed, A. (2015). Small farmers and sustainability: Institutional barriers to investment and innovation in the Malaysian palm oil industry in Sabah. Journal of Rural Studies, 40, 46-58.

Martín-Martín, A., Orduna-Malea, E., Thelwall, M., & López-Cózar, E. D. (2018). Google Scholar, Web of Science, and Scopus: A systematic comparison of citations in 252 subject categories. Journal of informetrics, 12(4), 1160-1177.

Matthews, R. B., Kropff, M. J., Horie, T., & Bachelet, D. (1997). Simulating the impact of climate change on rice production in Asia and evaluating options for adaptation. Agricultural systems, 54(3), 399-425.

Mayer, A. L. (2008). Strengths and weaknesses of common sustainability indices for multidimensional systems. Environment international, 34(2), 277-291.

Mayring, P. (2021). Qualitative content analysis: A step-by-step guide.

Mazziotta, M., & Pareto, A. (2022). Normalization methods for spatio-temporal analysis of environmental performance: Revisiting the Min–Max method. Environmetrics, 33(5), e2730.

McDowell, R., Dodd, R., Pletnyakov, P., & Noble, A. (2020). The ability to reduce soil legacy phosphorus at a country scale. Frontiers in Environmental Science, 8, 6.

Meadows, D. H., Randers, J., & Meadows, D. L. (2013). The limits to growth (1972). In The future of nature (pp. 101-116). Yale University Press.

Mebratu, D. (1998). Sustainability and sustainable development: historical and conceptual review. Environmental impact assessment review, 18(6), 493-520.

Mercado, T. J. S., Buenavista, M. J. M., Pascual, M. D., & Badua, A. E. (2025). Assessing the adoption of specialized rice production technology in selected towns of Nueva Ecija. Asian Journal of Agriculture and Rural Development, 15(2), 291.

Merli, R., Preziosi, M., & Acampora, A. (2018). Sustainability experiences in the wine sector: toward the development of an international indicators system. Journal of cleaner production, 172, 3791-3805.

Meshram, S., Mansor, H. B., & Adhikari, T. B. (2026). Recent advances in organic agriculture: innovations, challenges, and opportunities. Frontiers in Plant Science, 16, 1681928.

Mikki, S. (2009). Google scholar compared to web of science. A literature review. Nordic journal of information literacy in higher education, 1(1).

Ministry of Agriculture and Food Industries Malaysia MAFs. (2021). Executive summary: National Agrofood Policy 2021–2030 (NAP 2.0): Agrofood modernisation: Safeguarding the future of national food security. Putrajaya, Malaysia: Ministry of Agriculture and Food Industries Malaysia.

Ministry of Agriculture and Food Security Malaysia MAFs. (2024). PINTAR. Retrieved May 12, 2026, from https://www.kpkm.gov.my/en/programs-and-initiatives/pintar

Mishra, H., & Mishra, D. (2025). Robotics, Drones, Remote Sensing, GIS, and IoT Tools for Agricultural Operations and Water Management. In Integrated Land and Water Resource Management for Sustainable Agriculture Volume 2 (pp. 21-49). Singapore: Springer Nature Singapore.

Mohamed, Z., Terano, R., Shamsudin, M. N., & Abd Latif, I. (2016). Paddy Farmers' Sustainability Practices in Granary Areas in Malaysia. Resources, 5(2), 17. https://doi.org/10.3390/resources5020017

Mohd Arifin, N. A., Ismail, N. A., Bakar, M. A., Syahlan, S., & Zulkifli, F. (2024). Barriers to myGAP certification: a study of farmer knowledge, intentions, and challenges in Kelantan, Malaysia. Borneo Akademika, 8(1), 53-62.

Mohd Ishar, N. I., Mior Harun, M. H., Hanif, A., Mustapha, N. A., Kusa, R., & Duda, J. (2024). Bibliometric Analysis on Digital Payment Using Lens.org and Vosviewers: A Comparison of Research Between Malaysia and Poland. Open research Europe, 4, 191. https://doi.org/10.12688/openreseurope.18248.1

Moldan, B., & Dahl, A. L. (2007). Challenges to sustainability indicators. Sustainability indicators: a scientific assessment, 1.

Moore, H. E., & Rutherfurd, I. D. (2020). Researching agricultural environmental behaviour: improving the reliability of self-reporting. Journal of Rural Studies, 76, 296-304.

Morgan, D. L. (2007). Paradigms lost and pragmatism regained: Methodological implications of combining qualitative and quantitative methods. Journal of Mixed Methods Research 1: 48–76.

Morgan, D. L. (2013). Integrating qualitative and quantitative methods: A pragmatic approach. Sage publications.

Morgan, H. (2022). Conducting a qualitative document analysis. The Qualitative Report, 27(1), 64-77.

Mori, K., & Christodoulou, A. (2012). Review of sustainability indices and indicators: Towards a new City Sustainability Index (CSI). Environmental Impact Assessment Review, 32(1), 94-106.

Morse, S. (2013). Indices and indicators in development: An unhealthy obsession with numbers. Routledge.

Mothupi, M. C., Knight, L., & Tabana, H. (2020). Improving the validity, relevance and feasibility of the continuum of care framework for maternal health in South Africa: a thematic analysis of experts' perspectives. Health research policy and systems, 18(1), 28.

Movahhed Moghaddam, S., Azadi, H., Sklenička, P., & Janečková, K. (2025). Impacts of Land Tenure Security on the Conversion of Agricultural Land to Urban Use. Land Degradation & Development, 36(8), 2517-2529.

Muazu, A., Yahya, A., Ishak, W. I. W., & Bejo, S. K. (2016). Optimization of energy use intensity using data envelopment analysis and benchmarking methodology for sustainable rice cultivation under wetland direct seeding conditions in Malaysia. Jurnal Teknologi (Sciences & Engineering), 78(1-2).

Muazu, A., Yahya, A., Ishak, W. I. W., & Khairunniza-Bejo, S. (2015). Energy audit for sustainable wetland paddy cultivation in Malaysia. Energy, 87, 182-191.

Mucharam, I., Rustiadi, E., Fauzi, A., & Harianto. (2020). Assessment of rice farming sustainability: evidence from Indonesia provincial data.

Mujio, Rusdiana, O., Ermyanyla, M., Siddiq, D., Supijatno, Rahayu, R. A., & Mohd Yusoff, Z. (2025). Assessing agricultural sustainability through economic, social, and ecology indicators: A case study in Luwu Regency, Indonesia. In BIO Web of Conferences (Vol. 186, p. 01007). EDP Sciences.

Mungkung, R., Sitthikitpanya, S., Chaichana, R., Bamrungwong, K., Santitaweeroek, Y., Jakrawatana, N., ... & Gheewala, S. H. (2022). Measuring sustainability performance of rice cultivation in Thailand using Sustainable Rice Platform indicators. International journal of agricultural sustainability, 20(7), 1278-1293.

Murad, W., Mustapha, N. H. M., & Siwar, C. (2009). Review of Malaysian agricultural policies with regards to sustainability.

Murali, S., Anchitaalagammai, J. V., Kavitha, S., & Flavin, A. (2024). Garden Irrigation System Using IOT. In 2024 11th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions)(ICRITO) (pp. 1-6). IEEE.

Mustafa, H., Johari, J., & Mahussin, N. (2016). Ethnicity, Accounting Record and the Productivity of Malaysian Paddy Farmers. International Journal of Agriculture, Forestry and Plantation

Nachtergaele, F., Biancalani, R., Bunning, S., & George, H. (2010). Land degradation assessment: the LADA approach. In 19th World Congress of Soil Science, Brisbane, Australia.

Nambiar, K. K. M., Gupta, A. P., Fu, Q., & Li, S. (2001). Biophysical, chemical and socio-economic indicators for assessing agricultural sustainability in the Chinese coastal zone. Agriculture, ecosystems & environment, 87(2), 209-214.

Nardo, M., Saisana, M., Saltelli, A., & Tarantola, S. (2005). A. Hoffman and E. Giovannini (OECD)(2005) Handbook on Constructing Composite Indicators: Methodology and Userguide. OECD Statistics Working Paper.

Nasution, M. A., Wulandari, A., Ahamed, T., & Noguchi, R. (2020). Alternative POME treatment technology in the implementation of roundtable on sustainable palm oil, Indonesian sustainable palm oil (ISPO), and Malaysian sustainable palm oil (MSPO) standards using LCA and AHP methods. Sustainability, 12(10), 4101.

Navarro, V., & Shi, L. (2001). The political context of social inequalities and health. International Journal of Health Services, 31(1), 1-21.

Nawaz, A., Rehman, A. U., Rehman, A., Ahmad, S., Siddique, K. H., & Farooq, M. (2022). Increasing sustainability for rice production systems. Journal of Cereal Science, 103, 103400.

Nawi, N. M., Isa, B. M., Aziz, S. A., & Mohd Kassim, M. S. (2024). Evaluation of Field Performance and Energy Consumption of a Medium-sized Combine Harvester for Harvesting Glutinous Rice in Malaysia. Pertanika Journal of Science & Technology, 33(3).

Nawik, N. S. M., Deros, B. M., Rahman, M. N. A., Sukadarin, E. H., Nordin, N., Tamrin, S. B. M., ... & Norzan, M. L. (2015). Conceptual design of semi-automatic wheelbarrow to overcome ergonomics problems among palm oil plantation workers. In IOP Conference Series: Materials Science and Engineering (Vol. 100, No. 1, p. 012045). IOP Publishing.

Nazuri, N. S., Rosnon, M. R., Ahmad, N., Suhaimi, S. S. A., Sharifuddin, J., & Wijekoon, R. (2022). Vindication of linking social capital capacity to urban agriculture: A paradigm of participation based on social empowerment in Klang Valley, Malaysia. Sustainability, 14(3), 1509.

Ndhlovu, E. (2025). Agriculture, autonomous development, and prospects for industrialization in Africa. Springer Nature.

Ness, B., Urbel-Piirsalu, E., Anderberg, S., & Olsson, L. (2007). Categorising tools for sustainability assessment. Ecological economics, 60(3), 498-508.

Nguyen, M. H., Van Ngo, T., Tran, A. Q., Vu, L. G., Phan, N. T., Pham, S. T., ... & Vu, H. M. (2024). Occupational accidents among rice farmers in Northern Vietnam. Scientific Reports, 14(1), 27243.

Niemeijer, D., & De Groot, R. S. (2008). A conceptual framework for selecting environmental indicator sets. Ecological indicators, 8(1), 14-25.

Nodin, M. N., Mustafa, Z., & Hussain, S. I. (2022). Assessing rice production efficiency for food security policy planning in Malaysia: A non-parametric bootstrap data envelopment analysis approach. Food Policy, 107, 102208.

Nodin, M. N., Mustafa, Z., & Hussain, S. I. (2023). Eco-efficiency assessment of Malaysian rice self-sufficiency approach. Socio-Economic Planning Sciences, 85, 101436.

Nordin, S. M., Lohana, S., Abd Razak, S. N., Kumar, V., Abdul Rashid, R., Ahmad Rizal, A. R., & Atmadji, E. (2023). Identification of opportunities for espousing green fertilizers technology among smallholder paddy farmers for higher productivity and environmental sustenance. Sage Open, 13(4), 21582440231218688.

Norton, Bryan G., and Michael A. Toman. "Sustainability: ecological and economic perspectives." Land Economics (1997): 553-568.

Nyimbili, F., & Nyimbili, L. (2024). Types of purposive sampling techniques with their examples and application in qualitative research studies.

Ochieng, J., Afari-Sefa, V., Muthoni, F., Kansiime, M., Hoeschle-Zeledon, I., Bekunda, M., & Thomas, D. (2022). Adoption of sustainable agricultural technologies for vegetable production in rural Tanzania: trade-offs, complementarities and diffusion. International Journal of Agricultural Sustainability, 20(4), 478-496.

Olembo, R. J. (1994). Can land use planning contribute to sustainability. The future of the land-mobilizing and integrating knowledge for land use options. John Wiley & Sons, Chichester, 369-376.

Oler, D., & Picconi, M. (2009). Implications of insufficient and excess cash for future performance. Available at SSRN 1092880.

Othman, Zakirah, Amran Muhammad, and Mohd Akib Abu Bakar. "A Sustainable Paddy Farming Practice in West Malaysia." International Journal of Interdisciplinary Social Sciences 5.2 (2010).

Panigrahi, A., Nikou, S., & Calabretta, G. (2025). The sustainability scale-up framework: A tool to design scale-up strategies for sustainable businesses. Sustainable Production and Consumption.

Park, J., & Savelyeva, T. (2022). An interpretive analysis of the 2030 Sustainable Development Goals in Hong Kong public universities. Asia pacific education review, 23(4), 543-558.

Parsons, S., & Bynner, J. (2005). Does numeracy matter more?.

Parzonko, H., Sonnino, R., & Timotijevic, L. (2025). 'Beyond inviting to the table': Engaging the farming community in food system governance in the US and the UK. Geoforum, 165, 104367.

Pavlovskaia, E. (2014). Sustainability criteria: their indicators, control, and monitoring (with examples from the biofuel sector). Environmental Sciences Europe, 26(1), 17.

Peace, A., Ramirez, A., Broeren, M. L., Coleman, N., Chaput, I., Rydberg, T., & Sauvion, G. N. (2018). Everyday Industry—Pragmatic approaches for integrating sustainability into industry decision making. Sustainable Production and Consumption, 13, 93-101.

Pedersen, C. S. (2018). The UN sustainable development goals (SDGs) are a great gift to business!. Procedia Cirp, 69, 21-24.

Perak, Malaysia. International Journal of Environmental Research and Public Health, 19(2), 731

Perzina, R., & Ramík, J. (2014). Microsoft Excel as a tool for solving multicriteria decision problems. Procedia Computer Science, 35, 1455-1463.

Petticrew, M., & Roberts, H. (2008). Systematic reviews in the social sciences: A practical guide. John Wiley & Sons.

Pham, T. T., Dang, H. L., Pham, N. T. A., & Dang, H. D. (2021). Adoption of contract farming for managing agricultural risks: a case study in rice production in the Mekong Delta, Vietnam. Journal of Agribusiness in Developing and Emerging Economies.

Pittman, E. (2023). Realist synthesis: An innovative approach to literature review for complex management phenomena. Advancing methodologies of conducting literature review in management domain, 137-159.

Polit, D. F., & Beck, C. T. (2006). The content validity index: are you sure you know what's being reported? Critique and recommendations. Research in nursing & health, 29(5), 489-497.

Polit, D. F., Beck, C. T., & Owen, S. V. (2007). Is the CVI an acceptable indicator of content validity? Appraisal and recommendations. Research in nursing & health, 30(4), 459-467

Popa, F., Guillermin, M., & Dedeurwaerdere, T. (2015). A pragmatist approach to transdisciplinarity in sustainability research: From complex systems theory to reflexive science. Futures, 65, 45-56.

Pourzand, F., & Bakhshoodeh, M. (2014). Technical effici ency and agricultural sustainability–technology gap of maize producers in F ars province of Iran. Environment, Development and Sustainability, 16(3), 671-688.

Poveda, C. (2023). Evaluating the effectiveness of Commercially Developed Appraisal Instruments (CDAIs) using composite indices to assess, compare, and rank the liveability, quality of living and sustainability performance of cities and communities. Challenges in Sustainability, 11(1), 1-18.

Prasetyo, T., Setiani, C., & Wulanjari, M. E. (2022). Cost efficiency and farmers' profit in using certified rice seeds and non-certified rice seeds in rainfed rice field. In E3S Web of Conferences (Vol. 361, p. 02027). EDP Sciences.

Pretty, J. (2008). Agricultural sustainability: concepts, principles and evidence. Philosophical Transactions of the Royal Society B: Biological Sciences, 363(1491), 447-465.

Pretty, J. N. (1995). Regenerating agriculture: policies and practice for sustainability and self-reliance (pp. viii+-320).

Pretty, J., Sutherland, W. J., Ashby, J., Auburn, J., Baulcombe, D., Bell, M., ... & Pilgrim, S. (2010). The top 100 questions of importance to the future of global agriculture. International journal of agricultural sustainability, 8(4), 219-236.

Price, D. D., McGrath, P. A., Rafii, A., & Buckingham, B. (1983). The validation of visual analogue scales as ratio scale measures for chronic and experimental pain. Pain, 17(1), 45-56.

Purvis, B., Mao, Y., & Robinson, D. (2019). Three pillars of sustainability: in search of conceptual origins. Sustainability science, 14(3), 681-695.

Qin, P., Wang, H., Tao, Z., Zhang, W., Wang, J., & Ma, P. (2024). Implementation and sustainability of best practice guidelines: a tale of three hospitals. JBI Evidence Implementation, 10-1097.

Rabu, M. R., & Shah, M. D. M. (2013). Food and livelihood security of the Malaysian paddy farmers. Economic and Technology Management Review, 8(1), 59-69.

Rachman, B., Ariningsih, E., Sudaryanto, T., Ariani, M., Septanti, K. S., Adawiyah, C. R., ... & Yuniarti, E. (2022). Sustainability status, sensitive and key factors for increasing rice production: A case study in West Java, Indonesia. Plos One, 17(12), e0274689.

Rahayu, L., Indra, L., & Rubiyanto, C. W. (2025). Multidimensional sustainability assessment of Inpari Nutri Zinc rice farming in Bantul, Indonesia, using the RAP-MDS approach.

Rahim, H., Engku Ariff, E. E., Ahmad Sobri, A., & Abdul Wahab, M. A. M. (2019). The assessment of input factors and technical efficiency of rice in IADA Seberang Perak, Kerian and Barat Laut Selangor. Economic and Technology Management Review, 14.

Rahim, H., Ghazali, M. S. S. M., Bookeri, M. A. M., Abu Bakar, B. H., Ariff, E. E. E., Rahman, M. S. A., & Wahab, M. A. M. A. (2022). Economic potential of rice precision farming in Malaysia: the case study of Fulcra Seberang Perak. Precision Agriculture, 1-18

Rahman, M. H. A., Sharaai, A. H., Ponrahono, Z., Ab Rahim, N. N. R. N., Bakar, N. A. A., Hanifah, N. A. S., ... & Shafawi, N. A. (2024). Systematic literature review on the application of the life cycle sustainability assessment in agricultural production. Journal of Sustainability Research, 6(4).

Rai, N., & Thapa, B. (2015). A study on purposive sampling method in research. Kathmandu: Kathmandu School of Law, 5(1), 8-15.

Ramli, N. A., Yusof, N. F. F. M., Zarkasi, K. Z., & Suroto, A. (2023). Biological and chemical composition related to particulate matter in open rice straw burning event: A mini review. In 7th International Conference on Environment 2021 (ICENV2021) (Vol. 2785, No. 1, p. 030011). AIP Publishing..

Ramli, N. H., Yusup, S., Kueh, B. W. B., Kamarulzaman, P. S. D., Osman, N., Rahim, M. A., ... & Ahmad, A. B. (2018). Effectiveness of biopesticides in enhancing paddy growth for yield improvement. Sustainable Chemistry and Pharmacy, 7, 1-8.

Rana, M. E., Shanmugam, K., Hameed, V. A., & Zer, B. Y. K. (2025). Revolutionizing Malaysian Agriculture With Ubiquitous Technologies: Bridging the Gap Between Tradition and Innovation. In 2025 International Conference on Advancements in Smart, Secure and Intelligent Computing (ASSIC) (pp. 1-6). IEEE.

Rani, P. (2019). Changing land use pattern in Haryana: a spatio-temporal study. International Journal of Research and Analytical Reviews, 6, 567-573.

Rasmussen, L. V., Bierbaum, R., Oldekop, J. A., & Agrawal, A. (2017). Bridging the practitioner-researcher divide: Indicators to track environmental, economic, and sociocultural sustainability of agricultural commodity production. Global environmental change, 42, 33-46.

Rayhan, M. J., Rahman, S. M., Mamun, A. A., Saif, A. N. M., Islam, K. A., Alom, M. M., & Hafiz, N. (2024). FinTech solutions for sustainable agricultural value chains: A perspective from smallholder farmers. Business Strategy & Development, 7(2), e358.

Redondo, P. V. T. (2016). Purposive sampling in the analysis of count data. Philipp Stat, 65, 41-52.

Reganold, J.P.; Papendick, R.I.; Parr, J.F. Sustainable Agriculture. Sci. Am. 1990, 262, 112–120.

Reid, J., & Rout, M. (2020). Developing sustainability indicators–The need for radical transparency. Ecological Indicators, 110, 105941.

Reinhart, C. M., & Rogoff, K. S. (2010). Growth in a Time of Debt. American economic review, 100(2), 573-578.

Relawati, R., Iriany, A., Prihartini, I., Ramli, M. F., & Tlogomas, R. (2022). Farmers' Willingness to Pay Bio-Activators to Maintain Soil Fertility. SOCA: J. Sosial Ekonomi Pertanian, 16(3), 234-245.

Renthlei, E., & George, A. (2025). Toward holistic neighbourhood sustainability assessment: integrating fuzzy Delphi method for sustainable indicator selection for Aizawl city. Local Environment, 30(5), 622-641.

Renzi, G., Canfora, L., Salvati, L., & Benedetti, A. (2017). Validation of the soil Biological Fertility Index (BFI) using a multidimensional statistical approach: A country-scale exercise. Catena, 149, 294-299.

Rezvani, M. R., Faraji Sabokbar, H. A., Darban Astaneh, A., & Karimi, S. H. (2017). Identification and validation of effective indicators and factors of environmental quality in branding of rural tourism destinations using thematic analysis method (Case: Ethno-cultural Region of Oramanat in Kurdistan and Kermanshah Provinces). Journal of Rural Research, 8(2), 318-345.

Riley, J. (2001). Indicator quality for assessment of impact of multidisciplinary systems. Agriculture, ecosystems & environment, 87(2), 121-128.

Robling, H., Hatab, A. A., Säll, S., & Hansson, H. (2023). Measuring sustainability at farm level–A critical view on data and indicators. Environmental and Sustainability Indicators, 18, 100258.

Rocha, C. S., Antunes, P., & Partidário, P. (2019). Design for sustainability models: A multiperspective review. Journal of Cleaner Production, 234, 1428-1445.

Roesch, A., Nyfeler-Brunner, A., & Gaillard, G. (2021). Sustainability assessment of farms using SALCAsustain methodology. Sustainable Production and Consumption, 27, 1392-1405.

Rohaeni, E. S., Mailena, L., Lesmayati, S., & Ermuna, S. S. (2021). Sustainability analysis for rice and duck farming in swampy land, Hulu Sungai Utara Regency, South Kalimantan. In IOP Conference Series: Earth and Environmental Science (Vol. 648, No. 1, p. 012134). IOP Publishing.

Rokeman, N. R. M. (2024). Likert measurement scale in education and social sciences: explored and explained. EDUCATUM Journal of Social Sciences, 10(1), 77-88.

Romanov, N. O., Skvortsova, D. A., Filin, N. A., Shvaiko, B. A., & Kuznetsov, A. A. (2025). Studying data normalization methods in the sustainable development indicators analysis. In 2025 7th International Youth Conference on Radio Electronics, Electrical and Power Engineering (REEPE) (pp. 1-4). IEEE.

Rosly, R. A. (2010). Transformasi industri padi PPK Tanjong Karang perkukuh rantaian nilai. Berita Transformasi Pertanian, Bil. 04/2010 (Edisi April). Lembaga Pertubuhan Peladang (LPP

Roundtable on Sustainable Palm Oil. (2019). RSPO independent smallholder standard for the production of sustainable palm oil. RSPO

Roy, R., Chan, N. W., & Rainis, R. (2014). Rice farming sustainability assessment in Bangladesh. Sustainability science, 9(1), 31-44.

Roy, R., Chan, N. W., & Xenarios, S. (2016). Sustainability of rice production systems: an empirical evaluation to improve policy. Environment, Development and sustainability, 18(1), 257-278.

Rozmi, A. N. A., Nordin, A., & Bakar, M. I. A. (2018). The perception of ICT adoption in small medium enterprise:

Rudiyanto, R., Chun, P. W. L., Sarudin, S. A., Soh, N. C., Shah, R. M., Rahman, R. A., ... & Shaffie, M. F. (2023). Mapping Paddy Rice Extent And Cropping Pattern In Iada Barat Laut Selangor Using Integration Of Sentinel-1 And 2 Data. Universiti Malaysia Terengganu Journal of Undergraduate Research, 5(3), 51-64.

Ruggerio, C. A. (2021). Sustainability and sustainable development: A review of principles and definitions. Science of the total environment, 786, 147481.

Rusli, N. M. B. R., Samah, R. S., & Kamaruddin, R. K. (2023). Technology readiness index of paddy farmers in MADA, KADA, and IADA BLS, Malaysia. Journal of Economics and Sustainability, 5(1), 27-42.

Ruysschaert, D., & Salles, D. (2014). Towards global voluntary standards: Questioning the effectiveness in attaining conservation goals: The case of the Roundtable on Sustainable Palm Oil (RSPO). Ecological Economics, 107, 438-446.

Sabiha, N. E., Salim, R., Rahman, S., & Rola-Rubzen, M. F. (2016). Measuring environmental sustainability in agriculture: A composite environmental impact index approach. Journal of environmental management, 166, 84-93.

Sabine, Wagenhals., Wendy, Garner., Les, Duckers., Katja, Kuhn. (2014). Sustainability Index with Integrated Indicator Dependencies. 12(1):15-29. doi: 10.3846/BME.2014.02

Sadeghi, F., Kalantari, D., & Kiani, S. (2023). Development of an intelligent machine vision system for online quality measurement of rice paddy. Innovative Food Technologies, 10(4), 335–357. https://doi.org/10.22104/ift.2023.6268.2141.

Sadok, W., Angevin, F., Bergez, J. E., Bockstaller, C., Colomb, B., Guichard, L., ... & Doré, T. (2009). MASC, a qualitative multi-attribute decision model for ex ante assessment of the sustainability of cropping systems. Agronomy for sustainable development, 29(3), 447-461.

Saiful Nathan, S. B., & Mohd Rosli, M. (2016). Distributional effects of non-farm incomes in a Malaysian rice bowl. International Journal of Social Economics, 43(2), 205-220.

Sais, H. A., & Benziouche, S. E. (2025). Assessing the sustainability of intensive olive farming in arid areas through multi-criteria analysis. An-Najah University Journal for Research-A (Natural Sciences), 40(3), None-None.

Santiago-Brown, I., Metcalfe, A., Jerram, C., & Collins, C. (2015). Sustainability assessment in wine-grape growing in the new world: Economic, environmental, and social indicators for agricultural businesses. Sustainability, 7(7), 8178-8204.

Santos, E. C., Moreno, M. F., Hernandez, A., Garcia, R. M., Spector, J. T., Ornelas, I. J., & Baquero, B. (2025). "A veces no aguantas lo pesado que es el trabajo": A qualitative study on work conditions, labor and social policies, and health among Latino agricultural workers in Washington State. SSM-Qualitative Research in Health, 7, 100507.

Sariam, O., & Anuar, A. R. (2010). Effects of irrigation regime on irrigated rice. J. Trop. Agric. and Df. Sc, 38(1), 1-9.

Sarwar, S. (2024). Advancing sustainable agriculture: A comprehensive analysis of integrated pest management strategies in global rice production. International Journal of Agriculture and Sustainable Development, 6(1), 1-14.

Sattler, C., Schrader, J., Flor, R. J., Keo, M., Chhun, S., Choun, S., ... & Settele, J. (2021). Reducing pesticides and increasing crop diversification offer ecological and economic benefits for farmers—A case study in Cambodian rice fields. Insects, 12(3), 267.

Schader, C., Grenz, J., Meier, M. S., & Stolze, M. (2014). Scope and precision of sustainability assessment approaches to food systems. Ecology and society, 19(3).

Schöggl, J. P., Fritz, M. M., & Baumgartner, R. J. (2016). Toward supply chain-wide sustainability assessment: a conceptual framework and an aggregation method to assess supply chain performance. Journal of Cleaner Production, 131, 822-835.

Schor, J. B. (2005). Prices and quantities: Unsustainable consumption and the global economy. Ecological Economics, 55(3), 309-320.

Scialabba, N. (2014). SAFA guidelines: sustainability assessment of food and agriculture systems. Food and Agriculture Organization of the United Nations.

Sekaran, U., & Bougie, R. (2016). Research methods for business: A skill building approach. john wiley & sons

Sharaai, A. H., Masri, M. F., & Kalvani, S. R. (2022). The social impact study through the life cycle of rice production at Selangor, Malaysia. Chemical Engineering Transactions, 97, 517-522.

Shari, Z., & Soebarto, V. (2017). Development of an office building sustainability assessment framework for Malaysia. Pertanika Journal of Social Sciences and Humanities, 25(3), 1449-72.

Shrivastava, P. (1995). 'The role of corporations in achieving ecological sustainability', Academy of Management Review, vol. 20, no. 4, pp. 936-960.

Shyu, C. W. (2014). Ensuring access to electricity and minimum basic electricity needs as a goal for the post-MDG development agenda after 2015. Energy for sustainable development, 19, 29-38.

Sibuar, A. A., Zulkafflee, N. S., Selamat, J., Ismail, M. R., Lee, S. Y., & Abdull Razis, A. F. (2022). Quantitative analysis and human health risk assessment of heavy metals in paddy plants collected from

Simarmata, T., Khais Proyoga, M., Herdiyantoro, D., Setiawati, M. R., Adinata, K., & Stöber, S. (2021). Climate resilient sustainable agriculture for restoring the soil health and increasing rice productivity as adaptation strategy to climate change in indonesia. In IOP conference series: Earth and environmental science (Vol. 748, No. 1, p. 012039). IOP Publishing.

Simon, D. (1989). Sustainable development: theoretical construct or attainable goal?. Environmental Conservation, 16(1), 41-48.

Şimşek, Ö. (2025). Harvesting sustainability: innovations and practices in modern agriculture. Green Technologies and Sustainability, 100192.

Singh, R. K., Murty, H. R., Gupta, S. K., & Dikshit, A. K. (2012). An overview of sustainability assessment methodologies. Ecological indicators, 15(1), 281-299.

Slätmo, E., Fischer, K., & Röös, E. (2017). The framing of sustainability in sustainability assessment frameworks for agriculture. Sociologia Ruralis, 57(3), 378-395.

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. Journal of business research, 104, 333-339.

Sofiadin, A. M. (2021). Measuring Triple Bottom Line benefits in sustainable e-learning: a framework and process. In 2020 6th IEEE Congress on Information Science and Technology (CiSt) (pp. 254-260). IEEE.

Solaymani, S. (2018). Impacts of climate change on food security and agriculture sector in Malaysia. Environment, Development and Sustainability, 20(4), 1575-1596.

Soldi, A., Aparicio Meza, M. J., Guareschi, M., Donati, M., & Insfrán Ortiz, A. (2019). Sustainability assessment of agricultural systems in Paraguay: A comparative study using FAO's SAFA framework. Sustainability, 11(13), 3745.

Spangenberg, J. H. (2017). Sustainable development: From catchwords to benchmarks and operational concepts. In Sustainable solutions (pp. 24-47). Routledge.

Spangenberg, J. H., Pfahl, S., & Deller, K. (2002). Towards indicators for institutional sustainability: lessons from an analysis of Agenda 21. Ecological indicators, 2(1-2), 61-77.

Sriphirom, P., Chidthaisong, A., & Towprayoon, S. (2019). Effect of alternate wetting and drying water management on rice cultivation with low emissions and low water used during wet and dry season. Journal of Cleaner Production, 223, 980-988.

Steinfeld, H., Gerber, P., Wassenaar, T. D., Castel, V., & De Haan, C. (2006). Livestock's long shadow: environmental issues and options. Food & Agriculture Org.

Stevens, S. S. (1946). On the theory of scales of measurement. Science, 103(2684), 677-680.

Stoop, W. A., Sabarmatee, S., Pushpalatha Sivasubramanian, P. S., Ravindra, A., Debashish Sen, D. S., Prasad, S. C., & Thakur, A. K. (2017). Opportunities for ecological intensification: lessons and insights from the System of Rice/crop Intensification-their implications for agricultural research and development approaches. CABI Reviews, (2017), 1-19.

Storkey, J., Maclaren, C., Bullock, J. M., Norton, L. R., Redhead, J. W., & Pywell, R. F. (2024). Quantifying farm sustainability through the lens of ecological theory. Biological Reviews, 99(5), 1700-1716.

Stuart, A. M., Pame, A. R. P., Vithoonjit, D., Viriyangkura, L., Pithuncharurnlap, J., Meesang, N., ... & Lampayan, R. M. (2018). The application of best management practices increases the profitability and sustainability of rice farming in the central plains of Thailand. Field Crops Research, 220, 78-87.

Suhaila, J., Deni, S. M., Zin, W. W., & Jemain, A. A. (2010). Trends in peninsular Malaysia rainfall data during the southwest monsoon and northeast monsoon seasons: 1975–2004. Sains Malaysiana, 39(4), 533-542.

Suharni, R., Chew, B. C., & Rizal, A. H. M. S. (2021). Green And Sustainability Criteria In Malaysia's Poultry Production And Management. Journal of Sustainability Science and Management, 16(5), 140-163.

Sujarwo, Suciati, L. P., Haryati, N., Meitasari, D., Zainuddin, A., Murtisari, R., ... & Aulia, B. M. (2023). Strategic Behavior of Small-Scale Farmers toward Sustainability of Rice Farming: A study of Entrepreneurial skill to Farming Performance. In IOP Conference Series: Earth and Environmental Science (Vol. 1153, No. 1, p. 012021). IOP Publishing.

Sujianto, Gunawan, E., Saptana, Syahyuti, Darwis, V., Ashari, ... & Marhendro. (2022). Farmers' perception, awareness, and constraints of organic rice farming in Indonesia. Open Agriculture, 7(1), 284-299.

Sujianto, S., Hasibuan, A. M., Ayu Putu Mahendri, I. G., Pribadi, E. R., Pujiharti, Y., Ardana, I. K., ... & Gunawan, E. (2024). Drivers of Organic Rice Adoption Among Smallholder Farmers: Implications for Sustainable Development. International Journal of Sustainable Development & Planning, 19(1). Sustainability science, 9, 31-44.

Sulaiman, S. S. (2020). Regulating good agriculture practices (Gaps) in enhancing sustainability of halal food: Malaysian experience. Malaysian Journal of Consumer and Family Economics, 24(2), 32-45.

Sulewski, P., & Kłoczko-Gajewska, A. (2018). Development of the sustainability index of farms based on surveys and FADN sample. Problems of Agricultural Economics, 3(356).

Sulewski, P., Kłoczko-Gajewska, A., & Sroka, W. (2018). Relations between agri-environmental, economic and social dimensions of farms' sustainability. Sustainability, 10(12), 4629.

Sulwani, M., Asmawi, M. Z., Ibrahim, I., & Dewan, A. (2025). Development of a framework for the food availability index for rice cultivation in Peninsular Malaysia. Planning Malaysia, 23(3), 379–393.

Suter, G. W., & Cormier, S. M. (2013). Pragmatism: A practical philosophy for environmental scientists. Integrated environmental assessment and management, 9(2), 181-184.

Syverson, C. (2016). The slowdown in manufacturing productivity growth. Brookings Briefs.

Taherdoost, H. (2016). Validity and reliability of the research instrument; how to test the validation of a questionnaire/survey in a research. International journal of academic research in management (IJARM), 5.

Taherdoost, H. (2019). What is the best response scale for survey and questionnaire design; review of different lengths of rating scale/attitude scale/Likert scale. International Journal of Academic Research in Management (IJARM), 8.

Taherdoost, H. (2022). Designing a questionnaire for a research paper: A comprehensive guide to design and develop an effective questionnaire. Asian Journal of Managerial Science, 11(1), 8-16.

Tait, J., & Morris, D. (2000). Sustainable development of agricultural systems: competing objectives and critical limits. Futures, 32(3-4), 247-260.

Talib, Shaidatul azdawiyah abdul, Idris, Wan mohd razi, Neng, Liew ju, Lihan, T., & Rasid, Muhammad zamir abdul. (2024). Impact of Climate Change and Ensuring Food Security: Challenges for Rice Production in Malaysia. SAINS MALAYSIANA, 53(12), 3277-3289.

Talukder, B., Hipel, K. W., & vanLoon, G. W. (2018). Using multi-criteria decision analysis for assessing sustainability of agricultural systems. Sustainable Development, 26(6), 781-799.

Talukder, B., W. Hipel, K., & W. vanLoon, G. (2017). Developing composite indicators for agricultural sustainability assessment: Effect of normalization and aggregation techniques. Resources, 6(4), 66.

Tan, B. T., Fam, P. S., Firdaus, R. R., Tan, M. L., & Gunaratne, M. S. (2021). Impact of climate change on rice yield in Malaysia: a panel data analysis. Agriculture, 11(6), 569.

Tan, S. T., Ho, W. S., Hashim, H., Lee, C. T., Taib, M. R., & Ho, C. S. (2015). Energy, economic and environmental (3E) analysis of waste-to-energy (WTE) strategies for municipal solid waste (MSW) management in Malaysia. Energy Conversion and Management, 102, 111-120.

Tapsir, S., ELINI, E. E., Roslina, A., Noorlidawati, A. H., HAFIZUDIN, Z. M., Hairazi, R., & Rosnani, H. (2019). Food security and sustainability: Malaysia agenda. Malaysian Applied Biology, 48(3), 1-9.

Taylor, D. C., Mohamed, Z. A., Shamsudin, M. N., Mohayidin, M. G., & Chiew, E. F. (1993). Creating a farmer sustainability index: a Malaysian case study. American journal of alternative agriculture, 8(4), 175-184.

Terano, R., & Mohamed, Z. (2013). Quality of life among farmers in selected granary areas in Malaysia. Eur. J. Soc. Sci, 41, 1450-2267.

Terano, R., Mohamed, Z., Shamsudin, M. N., & Latif, I. A. (2015). Farmers sustainability index: The case of paddy farmers in state of Kelantan, Malaysia. Journal of the International Society for Southeast Asian Agricultural Sciences, 21(1), 55-67.

Terry, G., Hayfield, N., Clarke, V., & Braun, V. (2017). Thematic analysis. The SAGE handbook of qualitative research in psychology, 2(17-37), 25.

Tey, Y. S., Li, E., Bruwer, J., Abdullah, A. M., Brindal, M., Radam, A., ... & Darham, S. (2014). The relative importance of factors influencing the adoption of sustainable agricultural practices: A factor approach for Malaysian vegetable farmers. Sustainability science, 9(1), 17-29.

The Washington Post. (2026). Iran war is crushing Asia’s farmers, threatening global food supply. Retrieved May 12, 2026, from https://www.washingtonpost.com/world/2026/05/09/iran-farms-thailand-food/

Thiele, L. P. (2016). Sustainability (2nd ed.). Polity Press.

Tiraieyari, N., Hamzah, A., & Samah, B. A. (2014). Organic farming and sustainable agriculture in Malaysia: organic farmers’ challenges towards adoption. Asian Social Science, 10(4), 1-7.

Tiyndel, G. J., Sanjay, Bhatia, J. K., Bishnoi, D. K., Papang, J. S., & Bhardwaj, N. (2025). Measuring farm sustainability index: priorities for sustaining livelihoods of farm households in Haryana, India. Scientific Reports, 15(1), 13962.

Tongco, M. D. C. (2007). Purposive sampling as a tool for informant selection. Ethnobotany Research and applications, 5, 147-158.

Tuyen, M. C., Sirisupluxana, P., Bunyasiri, I., & Hung, P. X. (2022). Stakeholders’ Preferences towards Contract Attributes: Evidence from Rice Production in Vietnam. Sustainability, 14(6), 3478. https://doi.org/10.3390/su14063478

ul Haq, S., & Boz, I. (2018). Developing a set of indicators to measure sustainability of tea cultivating farms in Rize Province, Turkey. Ecological Indicators, 95, 219-232.

Umar, T. (2022). Developing an Integrated Sustainability Management Approach for Higher Education Institutions. International Journal of Social Ecology and Sustainable Development (IJSESD), 13(1), 1-19.

UNDP, 1990. Human Development Report 1990. Oxford University Press, New York.

Ustaoglu, E., Lopez, G. O., & Gutierrez-Alcoba, A. (2025). Building composite indicators for the territorial quality of life assessment in European regions: combining data reduction and alternative weighting techniques. Environment, Development and Sustainability, 27(3), 6025-6063.

Usubiaga-Liaño, A., & Ekins, P. (2024). Methodological choices for reflecting strong sustainability in composite indices. Ecological Economics, 221, 108192.

Vaghefi, N., Shamsudin, M. N., Radam, A., & Rahim, K. A. (2016). Impact of climate change on food security in Malaysia: economic and policy adjustments for rice industry. Journal of integrative environmental sciences, 13(1), 19-35.

Valizadeh, N., & Hayati, D. (2021). Development and validation of an index to measure agricultural sustainability. Journal of Cleaner Production, 280, 123797.

Van Cauwenbergh, N., Biala, K., Bielders, C., Brouckaert, V., Franchois, L., Cidad, V. G., ... & Peeters, A. (2007). SAFE—A hierarchical framework for assessing the sustainability of agricultural systems. Agriculture, ecosystems & environment, 120(2-4), 229-242.

Van Eck, N., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. scientometrics, 84(2), 523-538.

Vazhnik, V., Parish, E. S., Dale, V. H., Dale, K. L., & Richard, T. L. (2018). Emergent properties of sustainability: Using agroecosystem indicators within spatial and temporal frameworks. In 2018 ASABE Annual International Meeting (p. 1). American Society of Agricultural and Biological Engineers.

Vecchione, G. (2010). EU rural policy: proposal and application of an agricultural sustainability index.

Vinci, G., Ruggieri, R., Ruggeri, M., & Prencipe, S. A. (2023). Rice production chain: environmental and social impact assessment—a review. Agriculture, 13(2), 340.

Von Soest, C. (2023). Why do we speak to experts? Reviving the strength of the expert interview method. Perspectives on Politics, 21(1), 277-287

Waas, T., Hugé, J., Block, T., Wright, T., Benitez-Capistros, F., & Verbruggen, A. (2014). Sustainability assessment and indicators: Tools in a decision-making strategy for sustainable development. Sustainability, 6(9), 5512-5534.

Wahid, N. F., Hassan, M. S., Apin, L., & Shafiei, M. W. M. (2024). Multifunctional Agriculture in Plantation as Solution Towards Food Security in National Agriculture Policy 2.0 (NAP 2.0) from the Selected Government Agencies Perspective: Case Study in Pekan Nanas Johor. PaperASIA, 40(6b), 257-264.

Warhurst, A. (2002). Sustainability indicators and sustainability performance management. Mining, Minerals and Sustainable Development [MMSD] project report, 43(1), 129-140.

Webster, J. P. G. (1997). Assessing the economic consequences of sustainability in agriculture. Agriculture, ecosystems & environment, 64(2), 95-102.

Webster, P. (1999). The challenge of sustainability at the farm level: presidential address. Journal of agricultural economics, 50(3), 371-387.

Wei, Y., Davidson, B., Chen, D., & White, R. (2009). Balancing the economic, social and environmental dimensions of agro-ecosystems: An integrated modeling approach. Agriculture, ecosystems & environment, 131(3-4), 263-273.

Wells, J. (2012). Complexity and sustainability. 1st Edition. Routledge.

Whittemore, R., Chao, A., Jang, M., Minges, K. E., & Park, C. (2014). Methods for knowledge synthesis: an overview. Heart & Lung, 43(5), 453-461.

Wiget, M., Müller, A., & Hilbeck, A. (2020). Main challenges and key features of indicator-based agroecological assessment frameworks in the context of international cooperation. Ecology and Society, 25(3), 1-20.

Wojewódzka-Wiewiórska, A., Kłoczko-Gajewska, A., & Sulewski, P. (2019). Between the social and economic dimensions of sustainability in rural areas—in search of farmers' quality of life. Sustainability, 12(1), 148.

Wong, H. L., Omar, S. A. S., Leong, M. C., Karim, M. A., & Daliman, S. (2021). A preliminary study on current agricultural practices among small-scale rice farmers in Kelantan, Malaysia. In IOP Conference Series: Earth and Environmental Science (Vol. 842, No. 1, p. 012059). IOP Publishing.

World Health Organization, & United Nations Children's Fund. (2022). State of the world's drinking water: an urgent call to action to accelerate progress on ensuring safe drinking water for all. World Health Organization.

WorldBank, 1999. World Development Indicators 1999. World Bank, Washington, DC.

Wu, J., & Wu, T. (2012). Sustainability indicators and indices: an overview. Handbook of sustainability management, 65-86.

Xangsayasane, P., Vongxayya, K., Phongchanmisai, S., Mitchell, J., & Fukai, S. (2019). Rice milling quality as affected by drying method and harvesting time during ripening in wet and dry seasons. Plant Production Science, 22(1), 98-106.

Yap, P., Rosdin, R., Abdul-Rahman, A. A. A., Omar, A. T., Mohamed, M. N., & Rahami, M. S. (2021). Malaysian sustainable palm oil (MSPO) certification progress for independent smallholders in Malaysia. In IOP Conference Series: Earth and Environmental Science (Vol. 736, No. 1, p. 012071). IOP Publishing.

Yasar, M., Siwar, C., & Firdaus, R. R. (2015). Assessing paddy farming sustainability in the Northern Terengganu Integrated Agricultural Development Area (IADA KETARA): A structural equation modelling approach. Pacific Science Review B: Humanities and Social Sciences, 1(2), 71-75.

Yokoyama, S., & Ali, A. K. (2009). Social capital and farmer welfare in Malaysia. Japan Agricultural Research Quarterly: JARQ, 43(4), 323-328.

Young, J. C., Calla, S., Lecuyer, L., & Skrimizea, E. (2022). Understanding the social enablers and disablers of pesticide reduction and agricultural transformation. Journal of Rural Studies, 95, 67-76.

Yusoff, M. S. B. (2019). ABC of content validation and content validity index calculation. Education in medicine journal, 11(2), 49-54.

Yusop, Z. B., Ahmed, K., Shirazi, S. M., & Zardari, N. H. (2015). Weighting methods and their effects on multi-criteria decision making model outcomes in water resources management. Springer.

Yusuf, Rachmiwati & Tang, Usman & Karnila, Rahman & Fuadi, Indra & Pato, Usman. (2020). Ecological sustainability of rice farms in Siak District, Riau, Indonesia. Biodiversitas Journal of Biological Diversity. 21. 10.13057/biodiv/d210847.

Yvonne Feilzer, M. (2010). Doing mixed methods research pragmatically: Implications for the rediscovery of pragmatism as a research paradigm. Journal of mixed methods research, 4(1), 6-16.

Zainol Abidin, A. Z., & Abu Dardak, R. (2023). Sociological Issues and Challenges of Rice Production in Malaysia. FFTC Journal of Agricultural Policy

Zakaria, M. B., & NARNA, G. (2022). An analysis of rice supply in Malaysia post Covid-19–from an agriculture-related fiqh perspective. International Journal of Academic Research in Accounting, Finance and Management Sciences, 12(2).

Zaman, N. B. K., Ali, J., & Othman, Z. (2019). Factors affecting adoption of paddy estate project among rice farmers for increasing rice production and supply. International Journal of Supply Chain Management, 8(5), 486–492

Zamanzadeh, V., Ghahramanian, A., Rassouli, M., Abbaszadeh, A., Alavi-Majd, H., & Nikanfar, A.-R. (2015). Design and Implementation Content Validity Study: Development of an instrument for measuring Patient-Centered Communication. Journal of Caring Sciences, 4(2), 165. https://doi.org/10.15171/JCS.2015.017

Zanarotti, M. C., & Pagani, L. (2015). Some considerations to carry out a composite indicator for ordinal data. Electronic Journal of Applied Statistical Analysis, 8(3), 382-395.

Zhen, L., & Routray, J. K. (2003). Operational indicators for measuring agricultural sustainability in developing countries. Environmental management, 32(1), 34-46.

Zhou, L., Tokos, H., Krajnc, D., & Yang, Y. (2012). Sustainability performance evaluation in industry by composite sustainability index. Clean Technologies and Environmental Policy, 14(5), 789-803.

Zhou, P., Ang, B. W., & Zhou, D. Q. (2010). Weighting and aggregation in composite indicator construction: A multiplicative optimization approach. Social indicators research, 96(1), 169-181.

Ziemba, P., Becker, A., & Becker, J. (2022). Models and Indices of Sustainability Assessment in the Energy Context. Energies, 15(24), 9465.

Zink, K. J. (2005). From industrial safety to corporate health management. Ergonomics, 48(5), 534-546.

Zossou, E., Van Mele, P., Vodouhe, S. D., & Wanvoeke, J. (2009). The power of video to trigger innovation: rice processing in central Benin. International journal of agricultural sustainability, 7(2), 119-129.

Zuo, Z. P. (2023). Environmental regulation, green credit, and farmers' adoption of agricultural green production technology based on the perspective of tripartite evolutionary game. Frontiers in Environmental Science, 11, 1268504

APPENDICES

APPENDIX 1A

Criteria and indicator NVIVO file source Google link

https://drive.google.com/drive/folders/1EDrD1eTPL2nk7AjnZaKkii2020pQlo4B?usp=sharing.

APPENDIX 2A

Inclusion of criteria and the indicator file Google link

https://drive.google.com/drive/folders/1H2CjOZ9gCZvuC4-Tgc1tsY04VZcJS-Fk?usp=sharing.

APPENDIX 3A

Exclusion of criteria and the indicator file Google link

https://drive.google.com/drive/folders/1Bopa3OL9pEQhFZHGSXFXzzY_bbWhuuxk?usp=sharing.

APPENDIX 4A

Detailed criteria, indicator information, and an interview procedure Google link

https://drive.google.com/drive/folders/12OwIXf0-OKADpdhZ2UvAnhcRKJjyqgy0?usp=sharing.

APPENDIX 5A

Research Ethic Approval

www.uitm.edu.my

UNIVERSITI TEKNOLOGI MARA

Pejabat
Timbalan Naib Canselor
(Penyelidikan dan Inovasi)

Reference : 600-TNCPI (5/1/6)
Our reference : REC/07/2024 (PG/MR/308)
Date : 17 محرم 1445H
23 July 2024

Mr Mohmmad Shafie Hairal Anam - 2022417228
(Supervisor: Assoc. Prof. Dr Alawi Hj Sulaiman)
Faculty of Plantation and Agrotechnology
UiTM Melaka Branch
Jasin Campus
77800 Merlimau
MELAKA

سلام عليكم ورحمة الله وبركاته and Greetings

Mr

APPROVAL LETTER - UiTM RESEARCH ETHICS COMMITTEE

Thank you for submitting your research proposal to the Research Ethics Committee (REC). After considering your application, the Committee approved your proposal titled "Development of a Comprehensive Sustainability Index for Rice Cultivation in Malaysia Based on Environmental, Social and Economic Dimensions" at Kampung Sungai Panjang, Sungai Besar, Selangor. Details of the approval are as follows:

Ref. number:	REC/07/2024 (PG/MR/308)
Approval Period:	23 July 2024 until 31 May 2025
Authorised personnel:	1. Mohmmad Shafie Hairal Anam 2. Assoc. Prof. Dr Alawi Hj Sulaiman 3. Assoc. Prof. Dr Abdul Kadir Othman 4. Dr Nabila Farhana Jamaludin

The UiTM Research Ethics Committee operates in accordance to the ICH Good Clinical Practice Guidelines, Malaysian Good Clinical Practice Guidelines and the Declaration of Helsinki. The approval of this project is conditional upon your continuing compliance with these guidelines and declaration.

We draw to your attention the requirement that a report on this research, must be submitted every 12 months from the date of the approval or on the completion of the project, whichever occurs first. Failure to submit reports will result in withdrawal of consent for the project to proceed. Amendments, if any, to the study documents are to be submitted to the REC for approval.

If you require further information, please contact the REC Secretariat at 03-55448069/03-55442794 or email at recsecretariat@uitm.edu.my.

اوسها، تقوى، موليا
"MALAYSIA MADANI"
"BERKHIDMAT UNTUK NEGARA"

Yours sincerely,

(EMERITUS PROFESSOR DATO' DR RAYMOND AZMAN ALI)
Chairman
UiTM Research Ethics Committee

c.c.: Deputy Rector (PJIM&A), UiTM Melaka Branch

Universiti Teknologi MARA
Aras 3, Bangunan Wawasan
40450 Shah Alam, Selangor, MALAYSIA
Tel: (+603) 5544 2004/2255
Faks: (+603) 5544 2070

ISO 9001:2015 No. Sijil: 10120156

UiTM di hatiku

www.uitm.edu.my

UNIVERSITI TEKNOLOGI MARA | Fakulti Perladangan dan Agroteknologi

No. Ruj : 600-UiTMKJ (FPA.23/1)
Tarikh : 4 شعبان 1445H
: 14 Februari 2024

MOHMMAD SHAFIE HAIRAL ANAM (2022417228)
Fakulti Perladangan dan Agroteknologi
UiTM Cawangan Melaka Kampus Jasin
77300 Merlimau
Melaka

السلام عليكم ورحمة الله وبركاته dan Salam Sejahtera

Tuan

SURAT PENGESAHAN KELULUSAN ETIKA PENYELIDIKAN OLEH JAWATANKUASA PENYELIDIKAN FAKULTI (JPF) FAKULTI PERLADANGAN DAN AGROTEKNOLOGI, UiTM

Dengan hormatnya perkara di atas dirujuk.

2. Merujuk kepada keputusan Jawatankuasa Penyelidikan Fakulti (JPF) bertarikh 14 Februari 2024 mesyuarat telah menyokong permohonan Etika Penyelidikan untuk kelulusan Jawatankuasa Etika Penyelidikan (REC) UiTM. Butiran adalah seperti berikut:

BIL	NAMA	NO PELAJAR	TAJUK	PROGRAM
1	MOHMMAD SHAFIE BIN HAIRAL ANAM	2022417228	Development of a Comprehensive Sustainability Index for Rice Cultivation in Malaysia Based on Environmental, Social and Economic Dimensions	(AT950)

3. Kerjasama dan perhatian berkaitan perkara ini amat dihargai didahului dengan ucapan terima kasih.

Sekian,

اوسها، تقوى، موليا
"MALAYSIA MADANI"
"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

PROF. MADYA Ts. DR. FAZLEEN ABDUL FATAH
Timbalan Dekan (Penyelidikan dan Jaringan Industri)

Fakulti Perladangan dan Agroteknologi
Universiti Teknologi MARA
Cawangan Melaka, Kampus Jasin
77300 Merlimau, Melaka, MALAYSIA
Tel: (+606) 264 5238/ 5236/ 5243/ 5244

ISO 9001:2015 No. Sijil: 10120156
UiTM di hatiku

APPENDIX 6A

Expert Invitational Letter

www.uitm.edu.my

UNIVERSITI TEKNOLOGI MARA | Fakulti Perladangan dan Agroteknologi

Rujukan Kami : 100-UiTMKJ(FPA.1/1)
Tarikh : 1445H شوال 28
7 Mei 2024

KEPADA YANG BERKENAAN
(seperti dilampiran)

السلام عليكم ورحمة الله تعالى وبركاته

Tuan

MEMOHON KEBENARAN UNTUK MENDAPATKAN MAKLUMAT DAN DATA BAGI TUJUAN KAJIAN PENYELIDIKAN

NAMA PELAJAR	:	MOHMMAD SHAFIE BIN HAIRAL ANAM
NO. PELAJAR	:	2022417228
PROGRAM	:	DOCTOR of PHILOSOPHY (Ph.D)
KOD PROGRAM	:	AT950
FAKULTI	:	PERLADANGAN DAN AGROTEKNOLOGI
TAJUK PENYELIDIKAN	:	*Development of a Comprehensive Sustainability Index for Rice Cultivation among Farmers in Malaysia based on Environmental, Social and Economic Dimensions*

Dengan segala hormatnya perkara di atas adalah dirujuk.

2. Dimaklumkan bahawa pelajar seperti nama di atas adalah pelajar dari Fakulti Perladangan dan Agroteknologi, Universiti Teknologi MARA, Cawangan Melaka, Kampus Jasin.

3. Pihak fakulti memohon jasa baik pihak tuan untuk memberikan kebenaran bagi pelajar ini untuk mendapatkan maklumat bagi tujuan kajian penyelidikan beliau. Sehubungan dengan itu pihak fakulti berharap pihak tuan dapat mempertimbangkan permohonan ini.

Segala kerjasama dan kelulusan daripada pihak tuan amatlah dihargai dan didahului dengan ucapan terima kasih.

Sekian.

اوسهاء تقوى، مليا

"MALAYSIA MADANI"
"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah

PROF. MADYA TS. DR. ZAITON SAPAK
Ketua Pusat Pengajian Pasca Siswazah
b.p. Dekan

s.k. 1. Prof. Madya Dr. Alawi bin Hj. Sulaiman
Penyelia Utama
2. Fail Pelajar

Pusat Pengajian Siswazah
Fakulti Perladangan dan Agroteknologi
Universiti Teknologi MARA
Cawangan Melaka, Kampus Jasin
77300 Merlimau, Melaka, MALAYSIA
Tel: (606) 264 5190 / 5182 / 5170 / 5177

ISO 9001:2015 No. Sijil: 10120156

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APPENDIX 7A

Detail Interview Analysis Google Drive Link

https://drive.google.com/drive/folders/1dlGXR_0PIhuZ910N8_e8EDzXPNftrJZQ?usp=sharing.

APPENDIX 8A

Finalised Sustainability Criteria Google Drive Link

https://drive.google.com/drive/folders/13vM-YgVSSjlb6ly7OVTsQ8-Gid7JqKEv?usp=sharing.

APPENDIX 9A

Mapping of Sub-indicator Google Drive Link

https://drive.google.com/drive/folders/1j6PpGuXl-DZ_P4qs1FxMzO1o_VoITF70?usp=sharing.

APPENDIX 10A

Second Round Content Validity Index of Sub-Indicator Google Drive Link

https://drive.google.com/drive/folders/1-Z1aB6FYLv6RhqmvjHibRDO9Lb4ZWRJ1?usp=sharing.

APPENDIX 11A

Asessment questionaire

UNIVERSITI TEKNOLOGI MARA

QUESTIONAIRE
SOAL SELIDIK

Research Title:
Development of a Comprehensive Sustainability Index for Rice Cultivation among Farmers in Malaysia Based on Environmental, Social and Economic Dimensions
Tajuk Kajian:
Pembangunan Indeks Kemampanan Komprehensif bagi Penanaman Padi dalam Kalangan Pesawah di Malaysia Berdasarkan Dimensi Alam Sekitar, Sosial dan Ekonomi

PART A: DEMOGRAPIC INFORMATION ***Part A: Maklumat demograpik***				
Name/*Nama*	:			
Age/*Umur*	:			
Gender/*Jantina*	:			
Marital status/ *Status Perkahwinan*	:			
Ethic group/ *Kempulan etnik*	:	Malay/*Melayu*	:	( )
		Indian/ *India*	:	( )
		Chinese/ *Cina*	:	( )
		Other/*Lain-lain*	:	( )
Education level/ *Tahap Pendidikan*	:	Primary/*Sekolah Renda*	:	( )
		SRP	:	( )
		SPM	:	( )
		MCE	:	( )
		STPM	:	( )
		HCE	:	( )
		Diploma	:	( )

		Degree/*Sarjana Muda* Master/*Sarjana* Ph.D./ *Doktor Falsafah* Professional Qualification/*Kelayakan professional)*	: : : :	( ) ( ) ( ) ( )
Block Area/ *Kawasan Block*	:			
Size of planted field/*Keluasan tanaman padi* Hectare/*Hektar or Lot*	:	( )	**Keping** atau **Lot**	
Paddy land status/*Status tanah padi*	:	Personal owned/*Pemilikan persendirian* Family owned/*Pemilikan Bersama keluarga* Rented land/ *Tanah Sewaan* Mixed owned/ *Pemilikan campuran*	: : : :	( ) ( ) ( ) ( )

PART B: ITEM AND QUESTIONAIRE/ *Item dan soalan soal selidik*

Please tick the box to indicate the scale you are giving based on the question and state the amount in the box provided. Each question has a different scale name, please select the scale based on the question read.

Sila ***bulatkan*** *pada kotak untuk menunjukkan skala yang anda berikan berdasarkan soalan dan nyatakan jumlah dalam kotak yang disediakan. Setiap soalan mempunyai nama skala yang berbeza, sila pilih skala berdasarkan soalan yang dibaca.*

Likert scale. Every sub-indicator has a different "name scale" (***conducted/ have/ used/ sell/ informed/ follow/ high/ variety/ input***)

- **(1) Not** (***conducted/ have/ used/ sell/ informed/ follow/ high/ variety/ input***)
- **(2) Rarely** (***conducted/ have/ used/ sell/ informed/ follow/ high/ variety/ input***)
- **(3) Occasionally** (***conducted/ have/ used/ sell/ informed/ follow/ high/ variety/ input***)
- **(4) Frequently** (***conducted/ have/ used/ sell/ informed/ follow/ high/ variety/ input***)
- **(5) Consistently** (***conducted/ have/ used/ sell/ informed/ follow/ high/ variety/ input***)

Skala likert. Setiap sub-penunjuk mempunyai "skala nama" yang berbeza (dijalankan / telah / digunakan / jual / dimaklumkan / ikut / tinggi / pelbagai / input)

- *Tidak (dijalankan/ telah/ digunakan/ jual/ dimaklumkan/ ikut/ tinggi/ pelbagai/ input)*
- *Jarang (dijalankan/ telah/ digunakan/ jual/ dimaklumkan/ ikut/ tinggi/ pelbagai/ input)*
- *Sekali-sekala (dijalankan/ telah/ digunakan/ jual/ dimaklumkan/ ikut/ tinggi/ pelbagai/ input)*
- *Kerap (dijalankan/ telah/ digunakan/ jual/ dimaklumkan/ ikut/ tinggi/ pelbagai/ input)*
- *Secara konsisten (dijalankan/ telah/ digunakan/ jual/ dimaklumkan/ ikut/ tinggi/ pelbagai/ input)*

Environmental Dimension
Dimensi Persekitaran

<table>
<tr><td colspan="6">Element: Air
Unsur: Udara
Criteria 1: Zero burning practices
Kriteria 1: Amalan pembakaran sifar
Indicator: Paddy Stubble and straw
Petunjuk: Tunggul Padi dan jerami</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Sub-indicator: Use of decaying material
Sub–penunjuk : Penggunaan bahan pereput</td></tr>
<tr><td colspan="6">Likert scale selection with the following statement: (1) Not used, (2) Rarely used, (3) Occasionally used, (4) Frequently used, and (5) Consistently used
Pemilihan skala likert dengan pernyataan berikut: (1) Tidak digunakan, (2) Jarang digunakan, (3) Kadang-kadang digunakan, (4) Kerap digunakan, dan (5) Digunakan secara konsisten</td></tr>
<tr><td>Do you use decaying materials (Microbe agent) for unburnt paddy stubble and straw?
Adakah anda menggunakan bahan pereput (agen mikrob) untuk tunggul padi dan jerami yang tidak bakar?</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Sub-indicator: Burning
Sub-penunjuk: Pembakaran</td></tr>
<tr><td colspan="6">Likert scale selection with the following statement: (1) Not conducted, (2) Rarely conducted, (3) Occasionally conducted, (4) Frequently conducted and (5) Consistently conducted
Pemilihan skala likert dengan pernyataan berikut: (1) Tidak dijalankan, (2) Jarang dijalankan, (3) Kadang-kadang dijalankan, (4) Kerap dijalankan dan (5) Dijalankan secara konsisten</td></tr>
<tr><td>Do you conduct open-burning practices based on the Environmental Quality Act 1974 [127 ACT] for open burning?
Adakah anda menjalankan amalan pembakaran terbuka berdasarkan Akta Kualiti Alam Sekeliling 1974 [127 AKTA] untuk pembakaran terbuka?</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Sub-indicator: Use of plough
Sub-penunjuk: Membajak</td></tr>
<tr><td colspan="6">Likert scale selection with the following statement: (1) Not conducted, (2) Rarely conducted, (3) Occasionally conducted, (4) Frequently conducted and (5) Consistently conducted
Pemilihan skala likert dengan pernyataan berikut: (1) Tidak dijalankan, (2) Jarang dijalankan, (3) Kadang-kadang dijalankan, (4) Kerap dijalankan dan (5) Dijalankan secara konsisten</td></tr>
<tr><td>Do you conduct a ploughing activity without burning paddy straw and stubble, and use decaying materials during the wet season?
Adakah anda menjalankan aktiviti membajak tanpa membakar jerami padi dan tunggul serta menggunakan bahan reput semasa musim hujan?</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Sub-indicator: Use for by-product
Sub-penunjuk: Pengunaan untuk produk sampingan</td></tr>
<tr><td colspan="6">Likert scale selection with the following statement: (1) Not sell, (2) Rarely sell, (3) Occasionally sell, (4) Frequently sell and (5) Consistently sell</td></tr>
</table>

Pemilihan skala likert dengan pernyataan berikut: ***(1) Tidak menjual, (2) Jarang menjual, (3) Kadang-kadang menjual, (4) Kerap menjual dan (5) Menjual secara konsisten***					
Do you sell paddy straw to third parties (service providers)? *Adakah anda menjual jerami padi kepada pihak ketiga (penyedia perkhidmatan)?*	**1**	**2**	**3**	**4**	**5**

Element: Water *Unsur: Air* **Criteria 2:** Water resources *Kriteria 2: Sumber air* **Indicator:** Water management *Petunjuk: Pengurusan air*					
Sub-indicator: Timely crop establishment *Sub-penunjuk: Pembangunan tanaman tepat pada masa*					
Likert scale selection with the following statement: **(1) Not follow, (2) Rarely follow, (3) Occasionally follow, (4) Frequently follow and (5) Consistently follow** *Pemilihan skala likert dengan pernyataan berikut**: (1) Tidak ikut, (2) Jarang ikut, (3) Sesekali ikut, (4) Kerap ikut dan (5) Ikut secara konsisten***					
Do you follow crop establishment according to the irrigation agency's timetable on time? *Adakah anda mengikuti pembangunan tanaman tepat pada masanya berdasarkan jadual waktu agensi pengairan?*	**1**	**2**	**3**	**4**	**5**
Sub-indicator: Informed water irrigation issue *Sub-penunjuk: Isu pengairan air yang dimaklumkan*					
Likert scale selection with the following statement: **(1) Not informed, (2) Rarely informed, (3) Occasionally informed, (4) Frequently informed and (5) Consistently informed** *Pemilihan skala likert dengan pernyataan berikut:* ***(1) Tidak dimaklumkan, (2) Jarang dimaklumkan, (3) Kadang-kadang dimaklumkan, (4) Kerap dimaklumkan dan (5) Dimaklumkan secara konsisten***					
Do you inform the irrigation agency of the water irrigation issue you faced as soon as possible? *Adakah anda segera memaklumkan kepada agensi pengairan mengenai isu pengairan air yang anda hadapi?*	**1**	**2**	**3**	**4**	**5**

Element: Land *Unsur: Tanah* **Criteria 3:** Pre-planting *Kriteria 3: Pra-penanaman*
Indicator: Land Suitability *Petunjuk: Kesesuaian Tanah* **Sub-indicator:** Concern form *Penunjuk kecil: Borang kebenaran*
Likert scale selection with the following statement: **(1) Not conducted, (2) Rarely conducted, (3) Occasionally conducted, (4) Frequently conducted and (5) Consistently conducted**

<table>
<tr><td colspan="6">Pemilihan skala likert dengan pernyataan berikut: (1) Tidak dijalankan, (2) Jarang dijalankan, (3) Kadang-kadang dijalankan, (4) Kerap dijalankan dan (5) Dijalankan secara konsisten</td></tr>
<tr><td>Do you conduct pre-planting after getting permission from the irrigation agency on the status of the paddy field’s pH and CEC before proceeding
Adakah anda menjalankan pra-penanaman selepas mendapat kebenaran daripada agensi pengairan mengenai status pH dan CEC sawah padi sebelum meneruskan?</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Indicator: Surveillance of Paddy Field
Penunjuk: Pengawasan Sawah Padi
Sub-indicator: Irrigation and Drainage System Functionality, Maintenance field bund (batas), Farm Road.
Sub-penunjuk: Kefungsian Sistem Pengairan dan Saliran, Penyelenggaraan lapangan (batas), Jalan Ladang.</td></tr>
<tr><td colspan="6">Likert scale selection with the following statement: (1) Not conducted, (2) Rarely conducted, (3) Occasionally conducted, (4) Frequently conducted and (5) Consistently conducted
Pemilihan skala likert dengan pernyataan berikut: (1) Tidak dijalankan, (2) Jarang dijalankan, (3) Kadang-kadang dijalankan, (4) Kerap dijalankan dan (5) Dijalankan secara konsisten</td></tr>
<tr><td>Do you conduct surveillance of the paddy field before pre-planting, such as (1) irrigation and drainage systems condition, (2) field bunds (batas) on your farm are strong, clean from vegetation, and free from leaks, and (3) the width of the farm road on your farm is at least 4.5 meters?
Adakah anda menjalankan pengawasan ke atas sawah padi sebelum pra-penanaman, seperti (1) keadaan sistem pengairan dan saliran, (2) sawah (batas) di ladang anda kukuh, bersih daripada tumbuh-tumbuhan, dan bebas daripada kebocoran, dan (3) lebar jalan ladang di ladang anda sekurang-kurangnya 4.5 meter?</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Indicator: Land preparation
Penunjuk: Penyediaan tanah
Sub-indicator: Land preparation schedule, empty field, and field supervision.
Sub-penunjuk: Jadual penyediaan tanah, padang kosong, dan pengawasan lapangan.</td></tr>
<tr><td colspan="6">Likert scale selection with the following statement: (1) Not followed, (2) Rarely followed, (3) Occasionally followed, (4) Frequently followed, and (5) Consistently followed
Pemilihan skala likert dengan pernyataan berikut: (1) Tidak diikuti, (2) Jarang diikuti, (3) Kadang-kadang diikuti, (4) Kerap diikuti, dan (5) Diikuti secara konsisten</td></tr>
<tr><td>Do you follow the land preparation practices, such as (1) using the “Rice Check Wheel”, (2) ensuring that the paddy fields are cleaned of straw, stubble, weeds, and wind rice before ploughing and (3) supervising land preparation activities to ensure they are carried out properly, either by being present yourself or by service providers?
Adakah anda mengikuti amalan penyediaan tanah, seperti (1) menggunakan “Rice Check Wheel”, (2) memastikan sawah padi dibersihkan daripada jerami, tunggul, rumpai, dan padi angin sebelum membajak dan</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
</table>

(3) menyelia aktiviti penyediaan tanah untuk memastikan ia dijalankan dengan baik, sama ada dengan hadir sendiri atau oleh penyedia perkhidmatan?					
Criteria 4: Harvesting and post-harvesting *Kriteria 4: Penuaian dan pasca penuaian*					
Indicator: Timing of harvest *Penunjuk: Masa penuaian* **Sub-indicator:** Drying and stalk visualisation *Sub-penunjuk: Pengeringan dan visualisasi tangkai*					
Likert scale selection with the following statement: **(1) Not conducted, (2) Rarely conducted, (3) Occasionally conducted, (4) Frequently conducted and (5) Consistently conducted** *Pemilihan skala likert dengan pernyataan berikut:* ***(1) Tidak dijalankan, (2) Jarang dijalankan, (3) Kadang-kadang dijalankan, (4) Kerap dijalankan dan (5) Dijalankan secara konsisten***					
Do you conduct drying and stalk visualisation practices, such as (1) drying the water in the paddy fields 10–14 days before harvesting, (2) waiting 24 hours before starting harvesting if rain occurs before harvesting, and (3) harvesting paddy when approximately 85–90% of the paddy grains in the stalk are yellow? *Adakah anda menjalankan amalan pengeringan dan pemerhatian tangkai, seperti (1) mengeringkan air di sawah 10–14 hari sebelum menuai, (2) menunggu 24 jam sebelum memulakan penuaian jika hujan berlaku sebelum menuai, dan (3) menuai padi apabila kira-kira 85–90% daripada biji padi dalam tangkai berwarna kuning?*	**1**	**2**	**3**	**4**	**5**
Indicator: Harvesting equipment *Penunjuk: Peralatan menuai* **Sub-indicator:** Maintenance of harvesting equipment *Sub-penunjuk: Penyelenggaraan peralatan penuaian*					
Likert scale selection with the following statement: **(1) Not conducted, (2) Rarely conducted, (3) Occasionally conducted, (4) Frequently conducted and (5) Consistently conducted** *Pemilihan skala likert dengan pernyataan berikut:* ***(1) Tidak dijalankan, (2) Jarang dijalankan, (3) Kadang-kadang dijalankan, (4) Kerap dijalankan dan (5) Dijalankan secara konsisten***					
Do you supervise post-harvesting handling practices, such as (1) cleaning equipment to prevent contamination and mixing of varieties, weeds, and pests, (2) adjusting machines (if used) to optimize settings and operations according to the crop and field conditions, (3) ensuring harvester operation by cutting ½ form the tip of tree height, adjusting the jib on the rake side, operating on the medium speed (<4km/h), and carefully handling the harvester? *Adakah anda mengawasi amalan pengendalian selepas penuaian, seperti (1) peralatan pembersihan untuk mengelakkan pencemaran dan percampuran varieti, rumpai, dan perosak, (2) mesin pelaras (jika digunakan) untuk mengoptimumkan tetapan dan operasi mengikut*	**1**	**2**	**3**	**4**	**5**

keadaan tanaman dan ladang, (3) memastikan operasi penuaian dengan memotong ½ bentuk hujung ketinggian pokok, dan laraskan kelajuan pada km, (<4km/h) dan berhati-hati mengendalikan penuai?					
Indicator: Post-harvest handling *Penunjuk: Pengendalian lepas tuai* **Sub-indicator:** Transport storage, 24-hour yield transfer timeframe, and representative of selling yield *Sub-penunjuk: Penyimpanan pengangkutan, jangka masa pemindahan hasil 24 jam dan wakil hasil jualan*					
Likert scale selection with the following statement: **(1) Not conducted, (2) Rarely conducted, (3) Occasionally conducted, (4) Frequently conducted and (5) Consistently conducted** *Pemilihan skala likert dengan pernyataan berikut:* ***(1) Tidak dijalankan, (2) Jarang dijalankan, (3) Kadang-kadang dijalankan, (4) Kerap dijalankan dan (5) Dijalankan secara konsisten***					
Do you conduct post-harvesting handling practices, such as (1) trucks carrying paddy covered with canvas, ensuring no leaks on the truck floors and walls to avoid loss of yield, (2) ensuring that the harvested paddy is sent to the drying canter or factory within 24 hours and (3) ensuring an authorized representative present when the paddy is graded at the paddy mill or buyer collection centre? *Adakah anda menjalankan amalan pengendalian selepas penuaian, seperti (1) lori yang membawa padi ditutup dengan kanvas, memastikan tiada kebocoran pada lantai dan dinding lori untuk mengelakkan kehilangan hasil, (2) memastikan padi yang dituai dihantar ke tempat pengeringan atau kilang dalam tempoh 24 jam dan (3) memastikan wakil padi yang diberi tanggungjawab hadir semasa digredkan di kilang padi atau tempat pengumpulan padi?*	**1**	**2**	**3**	**4**	**5**

Element: Material and Energy *Elemen: Bahan dan Tenaga* **Criteria 5:** Efficiency of energy use *Kriteria 5: Kecekapan penggunaan tenaga*	
Indicator: Non-renewable energy consumption *Penunjuk: Penggunaan tenaga tidak boleh diperbaharui* **Sub-indicator:** Use of diesel *Penunjuk kecil: Penggunaan diesel*	
Secondary Data: Total used of diesel (RM/Year) *Data sekunder: Jumlah Penggunaan diesel (Mt)/Setahun)*	***/ 1 keping atau 1 lot***
Sub-indicator: Use of Gasoline/ Petrol *Sub-penunjuk: Penggunaan Petrol*	
Secondary Data: Total used of diesel (RM/Year)	***/ 1 keping atau 1 lot***

<table>
<tr><td colspan="3">Data sekunder: Jumlah Penggunaan diesel (RM/setahun)</td><td colspan="3"></td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Indicator: Mechanism of action for reducing non-renewable energy consumption
Penunjuk: Tindakan mekanisme untuk mengurangkan penggunaan tenaga tidak boleh diperbaharui
Sub-indicator: Use of service provider and own machinery
Sub-penunjuk: Digunakan pembekal perkhidmatan</td></tr>
<tr><td colspan="6">Likert scale selection with the following statement: (1) Not used, (2) Rarely used, (3) Occasionally used, (4) Frequently used and (5) Consistently used
Pemilihan skala likert dengan pernyataan berikut: (1) Tidak digunakan, (2) Jarang digunakan, (3) Kadang-kadang digunakan, (4) Kerap digunakan dan (5) Digunakan secara konsisten</td></tr>
<tr><td>Do you use service providers and own machinery for harvesting and post-harvesting activities?
Adakah anda menggunakan pembekal perkhidmatan, dimiliki atau kedua-dua jentera dalam aktiviti penuaian dan selepas penuaian?</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
</table>

<table>
<tr><td colspan="6">Criteria 6: Waste management and disposal
Kriteria 6: Pengurusan dan pelupusan sisa</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Indicator: Waste management standard operation procedure
Penunjuk: Prosedur operasi standard pengurusan sisa
Sub-indicator: Waste management hierarchy of control
Sub-penunjuk: Hierarki kawalan pengurusan sisa</td></tr>
<tr><td colspan="6">Likert scale selection with the following statement: (1) Not had, (2) Rarely had, (3) Occasionally had, (4) Frequently had, and (5) Consistently had
Pemilihan skala likert dengan pernyataan berikut: (1) Tidak ada, (2) Jarang ada, (3) Kadang-kadang ada, (4) Kerap ada, dan (5) Konsistent ada</td></tr>
<tr><td>Do you have a standard procedure or guideline for managing waste on your farm, such as handling paddy straw, stubble, or other agricultural waste?
Adakah anda mempunyai prosedur atau garis panduan standard untuk menguruskan sisa di ladang anda, seperti mengendalikan jerami padi, tunggul atau sisa pertanian lain?</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Indicator: Farm operational disposal
Penunjuk: Pelupusan operasi ladang
Sub-indicator: Solid and liquid waste of agricultural machinery and equipment
Sub-penunjuk: Sisa pepejal jentera pertanian dan sisa peralatan</td></tr>
<tr><td colspan="6">Likert scale selection with the following statement: (1) Not discard, (2) Rarely discard, (3) Occasionally discard, (4) Frequently discard, and (5) Consistently discard
Pemilihan skala likert dengan pernyataan berikut: (1) Tidak buang, (2) Jarang buang, (3) Sekali-sekala buang, (4) Kerap buang, dan (5) Buang secara konsisten</td></tr>
<tr><td>Do you discard your solid and liquid waste of agricultural machinery and equipment waste in a designated area managed by the agriculture department and the irrigation agency?
Adakah anda membuang sisa pepejal dan cecair sisa jentera dan peralatan pertanian di kawasan yang</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
</table>

<table>
<tr><td>ditetapkan yang diuruskan oleh jabatan pertanian dan agensi pengairan?</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><td colspan="6">Criteria 7: Planting material
Kriteria 7: Bahan penanaman</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Indicator: Pure quality seed
Penunjuk: Benih berkualiti tulen
Sub-indicator: Receive seed from a certified seed provider
Sub-penunjuk:Terima benih daripada pembekal benih bertauliah</td></tr>
<tr><td colspan="6">Likert scale selection with the following statement: (1) Not conducted, (2) Rarely conducted, (3) Occasionally conducted, (4) Frequently conducted and (5) Consistently conducted
Pemilihan skala likert dengan pernyataan berikut: (1) Tidak dijalankan, (2) Jarang dijalankan, (3) Kadang-kadang dijalankan, (4) Kerap dijalankan dan (5) Dijalankan secara konsisten</td></tr>
<tr><td>Do you conduct pure quality seed practices, such as (1) recording the variety name, purity, batch number, and vendor and (2) buying or receiving paddy seed or seedling from the certified provider or recognised farmer member and surrounding community?
Adakah anda menjalankan amalan benih berkualiti tulen, seperti (1) merekodkan nama varieti, ketulenan, nombor kelompok dan vendor dan (2) membeli atau menerima benih padi atau anak benih daripada pembekal bertauliah, ahli peladang and komuniti sekitar yang dikenali?</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
</table>

<table>
<tr><td colspan="2">Criteria 8: Pest Input
Kriteria 8: Input Perosak</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Indicator: Chemical pesticide
Penunjuk: Racun perosak kimia
Sub-indicator: Amount of chemical pesticide consumption
Sub-penunjuk: Jumlah penggunaan racun perosak kimia</td></tr>
<tr><td>Secondary Data: (RM/Year)
Data Sekunder: (RM/Setahun)</td><td>/ 1 keping atau 1 lot</td></tr>
<tr><td colspan="2">Sub-indicator: Organic pesticide (Natural ingredients)
Sub-penunjuk: Racun perosak organik (Bahan semulajadi)</td></tr>
<tr><td>Secondary Data: (RM/Year)
Data Sekunder: (RM/Setahun)</td><td>/ 1 keping atau 1 lot</td></tr>
</table>

<table>
<tr><td colspan="2">Criteria 9: Fertilizer Input
Kriteria 9: Input Baja</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Indicator: Chemical fertilizer
Penunjuk: Baja kimia
Sub-indicator: Amount of chemical fertilizer consumption
Penunjuk kecil: Jumlah penggunaan baja kimia</td></tr>
<tr><td>Secondary Data: (RM/Year)
Data Sekunder: (RM/Setahun)</td><td>/ 1 keping atau 1 lot</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Indicator: Organic fertilizer
Penunjuk: Baja organik</td></tr>
</table>

<table>
<tr><td colspan="2">Sub-indicator: Amount of biological fertilizer consumption
Sub-penunjuk: Jumlah penggunaan baja biologi</td></tr>
<tr><td>Secondary Data: (RM/Year)
Data Sekunder: (RM/Setahun)</td><td>/ 1 keping atau 1 lot</td></tr>
</table>

<table>
<tr><td colspan="6">Element: Biodiversity
Elemen: Biodiversiti
Criteria 10: Species Diversity
Kriteria 10: Kepelbagaian Spesies
Indicator: Integrated Pest Management (IPM)
Penunjuk: Pengurusan Perosak Bersepadu (IPM)</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Sub-indicator: Weed management
Sub-penunjuk: Pengurusan rumpai</td></tr>
<tr><td colspan="6">Likert scale selection with the following statement: (1) Not conducted, (2) Rarely conducted, (3) Occasionally conducted, (4) Frequently conducted and (5) Consistently conducted
Pemilihan skala likert dengan pernyataan berikut: (1) Tidak dijalankan, (2) Jarang dijalankan, (3) Kadang-kadang dijalankan, (4) Kerap dijalankan dan (5) Dijalankan secara konsisten</td></tr>
<tr><td>Do you conduct weed management practices such as:
• Conduct curative methods (e.g., manual and mechanical weeding), use an organic herbicide and use a chemical herbicide suggested by the government agency that does not come from non-counterfeit sources.
• Conduct and remind service providers to apply organic and chemical herbicides to avoid non-application zones, follow the product label instructions, follow specified preharvest intervals and not exceed the prescribed dosage (for worker safety and food safety), as suggested by the agriculture agency.
Adakah anda menjalankan amalan pengurusan rumpai seperti:
• Menjalankan kaedah kuratif (cth., merumput manual dan mekanikal), menggunakan racun rumpai organik dan menggunakan racun rumpai kimia yang dicadangkan oleh agensi kerajaan yang bukan berasal daripada sumber bukan tiruan.
• Menjalankan dan mengingatkan penyedia perkhidmatan untuk menggunakan racun rumpai organik dan kimia untuk mengelakkan zon bukan penggunaan, ikut arahan label produk, ikut selang prapenuaian yang ditetapkan dan tidak melebihi dos yang ditetapkan (untuk keselamatan pekerja dan keselamatan makanan), seperti yang dicadangkan oleh agensi pertanian.</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Sub-indicator: Insect management
Sub-penunjuk: Pengurusan serangga</td></tr>
</table>

<table>
<tr><td colspan="6">Likert scale selection with the following statement: (1) Not conducted, (2) Rarely conducted, (3) Occasionally conducted, (4) Frequently conducted and (5) Consistently conducted
Pemilihan skala likert dengan pernyataan berikut: (1) Tidak dijalankan, (2) Jarang dijalankan, (3) Kadang-kadang dijalankan, (4) Kerap dijalankan dan (5) Dijalankan secara konsisten</td></tr>
<tr><td>Do you conduct insect management practices, such as
Conduct curative methods (e.g., insect pheromones, biological control agents), use an organic insecticide and use a chemical insecticide suggested by the government agency that does not come from non-counterfeit sources.
Conduct a broad-spectrum insecticide that is not used within the first 40 days after planting in the production.
Conduct and remind service providers that insecticide application is targeted to avoid non-application zones, application method is according to the product label instructions, specified preharvest intervals, and not exceed the specified dosage (for worker safety and food safety), as suggested by the agriculture agency.
Adakah anda menjalankan amalan pengurusan serangga, seperti
Menjalankan kaedah kuratif (cth., feromon serangga, agen kawalan biologi), gunakan racun serangga organik dan gunakan racun serangga kimia yang dicadangkan oleh agensi kerajaan yang bukan berasal daripada sumber bukan tiruan.
Menjalankan racun serangga spektrum luas yang tidak digunakan dalam tempoh 40 hari pertama selepas ditanam dalam pengeluaran.
Menjalankan dan mengingatkan penyedia perkhidmatan bahawa penggunaan racun serangga disasarkan untuk mengelakkan zon bukan penggunaan, kaedah permohonan adalah mengikut arahan label produk, selang prapenuaian yang ditetapkan, dan tidak melebihi dos yang ditetapkan (untuk keselamatan pekerja dan keselamatan makanan), seperti yang dicadangkan oleh agensi pertanian.</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Sub-indicator: Disease management
Sub-penunjuk: Pengurusan penyakit</td></tr>
<tr><td colspan="6">Likert scale selection with the following statement: (1) Not conducted, (2) Rarely conducted, (3) Occasionally conducted, (4) Frequently conducted and (5) Consistently conducted
Pemilihan skala likert dengan pernyataan berikut: (1) Tidak dijalankan, (2) Jarang dijalankan, (3) Kadang-kadang dijalankan, (4) Kerap dijalankan dan (5) Dijalankan secara konsisten</td></tr>
<tr><td>Do you conduct disease management practices, such as
Conduct curative methods (e.g., biological control agent), use an organic fungicide and use</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
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<tr><td>

a chemical fungicide suggested by the government agency that does not come from non-counterfeit sources.

- Conduct and remind service providers targeted to non-application zones, apply according to the product label follow the specified preharvest interval (which is at least 30 days before harvest), not exceed the prescribed dosage (for worker safety and food safety), target disease type, considers recent history of fungal disease and predicted weather patterns, and considers local information on fungicide-resistant diseases as suggested by the government agency.

Adakah anda menjalankan amalan pengurusan penyakit, seperti

- *Menjalankan kaedah kuratif (cth., agen kawalan biologi), gunakan racun kulat organik dan gunakan racun kulat kimia yang dicadangkan oleh agensi kerajaan yang bukan berasal daripada sumber bukan tiruan.*
- *Menjalankan dan mengingatkan pembekal perkhidmatan yang disasarkan kepada zon bukan aplikasi, memohon mengikut label produk mengikut selang prapenuaian yang ditetapkan (iaitu sekurang-kurangnya 30 hari sebelum menuai), tidak melebihi dos yang ditetapkan (untuk keselamatan pekerja dan keselamatan makanan), jenis penyakit sasaran, mengambil kira sejarah penyakit kulat terkini dan corak cuaca yang diramalkan, dan mengambil kira maklumat tempatan mengenai penyakit tahan racun kulat oleh agensi kerajaan.*

</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Sub-indicator: Mollusc management
Sub-penunjuk: Pengurusan moluska (Siput)</td></tr>
<tr><td colspan="6">Likert scale selection with the following statement: (1) Not conducted, (2) Rarely conducted, (3) Occasionally conducted, (4) Frequently conducted and (5) Consistently conducted
Pemilihan skala likert dengan pernyataan berikut: (1) Tidak dijalankan, (2) Jarang dijalankan, (3) Kadang-kadang dijalankan, (4) Kerap dijalankan dan (5) Dijalankan secara konsisten</td></tr>
<tr><td>

Do you conduct mollusc management practices, such as

- Conduct curative methods (e.g., biological control), use an organic molluscicide and use a chemical molluscicide suggested by the government agency that does not come from non-counterfeit sources.
- Conduct and remind service provider targeted to non-application zones, apply according to the product label, follow specified preharvest interval, does not exceed specified dosage (for worker safety and food safety), target specific mollusc and use only within the first 3 weeks

</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
</table>

after crop establishment as suggested by the government agency? *Adakah anda menjalankan amalan pengurusan moluska* ***(Siput)****, seperti* • *Menjalankan kaedah kuratif (cth., kawalan biologi), gunakan moluskisida organik dan gunakan moluskisida kimia yang dicadangkan oleh agensi kerajaan yang bukan berasal daripada sumber bukan tiruan.* • *Menjalankan dan mengingatkan pembekal perkhidmatan yang disasarkan kepada zon bukan aplikasi, memohon mengikut label produk, mengikut selang prapenuaian yang ditetapkan, tidak melebihi dos yang ditetapkan (untuk keselamatan pekerja dan keselamatan makanan), menyasarkan moluska khusus dan hanya digunakan dalam tempoh 3 minggu pertama selepas penanaman tanaman seperti yang dicadangkan oleh agensi kerajaan?*					
Sub-indicator: Rodent management *Sub-penunjuk: Pengurusan tikus*					
Likert scale selection with the following statement: **(1) Not conducted, (2) Rarely conducted, (3) Occasionally conducted, (4) Frequently conducted and (5) Consistently conducted** *Pemilihan skala likert dengan pernyataan berikut****: (1) Tidak dijalankan, (2) Jarang dijalankan, (3) Kadang-kadang dijalankan, (4) Kerap dijalankan dan (5) Dijalankan secara konsisten***					
Do you conduct rodent management practices, such as. • Conducted curative methods (e.g., trapping, hunting, promotion of predators), use an organic rodenticide and a chemical rodenticide suggested by the government agency that does not come from non-counterfeit sources. • Conduct and remind service provider targeted to non-application zones, apply according to product label, follow specified preharvest interval, does not exceed specified dosage (for worker safety and food safety), respond to target rodent species, is used before the reproductive growth phase of the crop to avoid an outbreak during grain filling, and is placed under protective cover (e.g., bamboo tubes, coconut husks) where not easily accessible to birds or exposed to rainfall as suggested by the government agency. *Adakah anda menjalankan amalan pengurusan tikus, seperti.* • *Menjalankan kaedah kuratif (cth., memerangkap, memburu, mempromosikan pemangsa), menggunakan racun tikus organik dan racun tikus kimia yang dicadangkan oleh agensi kerajaan yang bukan berasal daripada sumber bukan tiruan.*	**1**	**2**	**3**	**4**	**5**

• *Menjalankan dan mengingatkan penyedia perkhidmatan yang disasarkan kepada zon bukan aplikasi, memohon mengikut label produk, ikut selang prapenuaian yang ditetapkan, tidak melebihi dos yang ditetapkan (untuk keselamatan pekerja dan keselamatan makanan), bertindak balas terhadap spesies tikus sasaran, digunakan sebelum fasa pertumbuhan pembiakan tanaman untuk mengelakkan wabak semasa pengisian bijirin, dan diletakkan di bawah penutup pelindung (cth., di mana buluh buluh tidak mudah diakses ke dalam kelapa, kelapa) seperti yang dicadangkan oleh agensi kerajaan.*					
Sub-indicator: Bird management *Sub-penunjuk: Pengurusan burung*					
Likert scale selection with the following statement: **(1) Not used, (2) Rarely used, (3) Occasionally used, (4) Frequently used and (5) Consistently used** Pemilihan skala likert dengan pernyataan berikut: **(1) Tidak digunakan, (2) Jarang digunakan, (3) Kadang-kadang digunakan, (4) Kerap digunakan dan (5) Digunakan secara konsisten**					
Do you use non-lethal bird control methods, such as synchronised planting, scare/deterrent devices, promotion of predators (e.g., birds of prey, shrikes), and chemical repellents that do not kill birds and have no negative side effects? *Adakah anda menggunakan kaedah kawalan burung yang tidak membawa maut seperti penanaman segerak, alat menakutkan/mencegah, promosi pemangsa (cth., burung pemangsa, shrikes), dan penghalau kimia yang tidak membunuh burung dan tanpa kesan sampingan negatif?*	**1**	**2**	**3**	**4**	**5**

Economic Dimension *Dimensi Ekonomi*	
Element: Transparency *Elemen: Ketelusan* **Criteria 11:** Traceability *Kriteria 11: Kebolehkesanan*	
Indicator: Record keeping *Penunjuk: Penyimpanan rekod* **Sub-indicator:** Input cost per year *Sub-penunjuk: Kos input setahun*	
Secondary Data: (RM/Year) *Data Sekunder: (RM/Setahun)*	***/ 1 keping atau 1 lot***
Sub-indicator: Yield per year *Sub-penunjuk: Hasil setahun*	
Secondary Data: (RM/Year) *Data Sekunder: (RM/Setahun)*	***/ 1 keping atau 1 lot***

Element: Vulnerability *Elemen: Keterdedahan* **Criteria 12:** Stability of Production

Kriteria 12: Kestabilan Pengeluaran					
Indicator: Guarantee of production levels *Penunjuk: Jaminan tahap pengeluaran* **Sub-indicator:** Diversification of paddy variety *Sub-penunjuk: Kepelbagaian varieti padi*					
Likert scale selection with the following statement: **(1) One Variety, (2) Two varieties, (3) Three varieties, (4) Four varieties and (5) More than four varieties** *Pemilihan skala likert dengan pernyataan berikut:* ***(1) Satu Varieti, (2) Dua varieti, (3) Tiga varieti, (4) Empat varieti dan (5) Lebih daripada empat varieti***					
Do you cultivate more than one paddy variety per year? *Adakah anda mengusahakan lebih daripada satu varieti padi setiap tahun?*	**1**	**2**	**3**	**4**	**5**
Sub-indicator: Diversification of income *Sub-penunjuk: Kepelbagaian pendapatan*					
Likert scale selection with the following statement: **(1) One income, (2) Two income, (3) Three income, (4) Four income and (5) More than four incomes** *Pemilihan skala likert dengan pernyataan berikut:* ***(1) Satu pendapatan, (2) Dua pendapatan, (3) Tiga pendapatan, (4) Empat pendapatan dan (5) Lebih daripada empat pendapatan***					
How many your income sources include paddy? *Berapa banyak sumber pendapatan anda termasuk padi?*	**1**	**2**	**3**	**4**	**5**
Sub-indicator: Access to Financial Instruments and Insurance *Sub-penunjuk:Akses kepada Instrumen Kewangan dan Insurans*					
Likert scale selection with the following statement **(1) Not have, (2) Rarely have, (3) Occasionally have, (4) Frequently have and (5) Consistently have** *Pemilihan skala likert dengan pernyataan berikut* ***(1) Tidak ada, (2) Jarang ada, (3) Kadang-kadang ada, (4) Kerap ada dan (5) Konsisten ada.***					
Do you have access to financial loans and insurance for paddy cultivation? *Adakah anda mempunyai akses kepada pinjaman kewangan dan insurans untuk penanaman padi?*	**1**	**2**	**3**	**4**	**5**
Sub-indicator: Social Networks and Collaboration *Sub-penunjuk: Rangkaian Sosial dan Kerjasama*					
Likert scale selection with the following statement **(1) Not joined, (2) Rarely joined, (3) Occasionally joined, (4) Frequently joined, and (5) Consistently joined** *Pemilihan skala likert dengan pernyataan berikut:* ***(1) Tidak menyertai, (2) Jarang menyertai, (3) Kadang-kadang menyertai, (4) Sering menyertai, dan (5) Menyertai secara konsisten***					
Have you joined any paddy farmer community or organisation? *Pernahkah anda menyertai mana-mana komuniti atau organisasi petani padi?*	**1**	**2**	**3**	**4**	**5**
Sub-indicator: Digital Tools and Technology Integration *Sub-penunjuk: Alat Digital dan Integrasi Teknologi*					
Likert scale selection with the following statement **(1) Not utilised, (2) Rarely utilised, (3) Occasionally utilised, (4) Frequently utilised, and (5) Consistently utilised**					

Pemilihan skala likert dengan pernyataan berikut: ***(1) Tidak digunakan, (2) Jarang digunakan, (3) Kadang-kadang digunakan, (4) Kerap digunakan, dan (5) Digunakan secara konsisten***					
Do you utilise digital tools and technology in paddy operations, such as cultivating online applications and using drones? *Adakah anda menggunakan alat digital dan integrasi teknologi dalam operasi padi, seperti penanaman aplikasi dalam talian dan penggunaan dron?*	**1**	**2**	**3**	**4**	**5**
Sub-indicator: Utilisation of Government and NGO Support Programs *Sub-penunjuk: Penggunaan Program Sokongan Kerajaan dan NGO*					
Likert scale selection with the following statement: **(1) Not utilised, (2) Rarely utilised, (3) Occasionally utilised, (4) Frequently utilised, and (5) Consistently utilised** *Pemilihan skala likert dengan pernyataan berikut:* **(1) Tidak digunakan, (2) Jarang digunakan, (3) Kadang-kadang digunakan, (4) Kerap digunakan, dan (5) Digunakan secara konsisten**					
Do you participate in government and NGO programs, such as irrigation agency supervision, NGO community events, and government-sponsored subsidized programs? *Adakah anda menyertai program kerajaan dan NGO seperti penyeliaan agensi pengairan, acara komuniti NGO, dan program bersubsidi oleh kerajaan?*	**1**	**2**	**3**	**4**	**5**

Criteria 13: Stability of Supply *Kriteria 13: Kestabilan Bekalan* **Indicator:** Procurement Channels/ Input Supplies *Penunjuk: Saluran Perolehan/ Bekalan Input*					
Sub-indicator: Record of Supplier Diversification *Sub-penunjuk: Rekod Kepelbagaian Pembekal*					
Likert scale selection with the following statement: **(1) One input, (2) Two inputs, (3) Three inputs, (4) Four inputs and (5) More than four inputs** *Pemilihan skala likert dengan pernyataan berikut:* ***(1) Satu input, (2) Dua input, (3) Tiga input, (4) Empat input dan (5) Lebih daripada empat input***					
Do you have more than one input supplier for your paddy cultivation? *Adakah anda mempunyai lebih daripada satu pembekal input untuk penanaman padi anda?*	**1**	**2**	**3**	**4**	**5**
Sub-indicator: Record of Contracts and Agreements *Sub-penunjuk: Rekod Kontrak dan Perjanjian*					
Likert scale selection with the following statement**: (1) Not have, (2) Rarely have, (3) Occasionally have, (4) Frequently have, and (5) Consistently have** *Pemilihan skala likert dengan pernyataan berikut:* ***(1) Tidak ada, (2) Jarang ada, (3) Kadang-kadang ada, (4) Kerap ada, dan (5) Konsisten ada.***					
Do you have a contract and agreement with your supplier on the input supply? *Adakah anda mempunyai kontrak dan perjanjian dengan pembekal anda mengenai bekalan input?*	**1**	**2**	**3**	**4**	**5**
Sub-indicator: Records of input supply shortages *Sub-penunjuk: Rekod kekurangan bekalan input*					

Likert scale selection with the following statement: **(1) Consistently faced, (2) Frequently faced, (3) Occasionally faced, (4) Rarely faced, and (5) Not faced** *Pemilihan skala likert dengan pernyataan berikut:* ***(1) Dihadapi secara konsisten, (2) Kerap dihadapi, (3) Kadang-kadang dihadapi, (4) Jarang dihadapi, dan (5) Tidak dihadapi***					
Did you face input supply shortages during operation? *Adakah anda menghadapi kekurangan bekalan input semasa operasi?*	**1**	**2**	**3**	**4**	**5**

Criteria 14: Liquidity *Kriteria 14: Kecairan* **Indicator:** Net Cash Flow *Penunjuk: Aliran Tunai Bersih*					
Sub-indicator: Record of positive net cash flow in the last five years *Sub-penunjuk: Rekod aliran tunai bersih yang positif dalam tempoh lima tahun yang lalu*					
Likert scale selection with the following statement: **(1) Not positive, (2) Rarely positive, (3) Occasionally positive, (4) Frequently positive, and (5) Consistently positive** *Pemilihan skala likert dengan pernyataan berikut:* ***(1) Tidak positif, (2) Jarang positif, (3) Kadang-kadang positif, (4) Kerap positif, dan (5) Positif secara konsisten***					
What is the status of Net Cash Flow from the last five years? *Apakah status Aliran Tunai Bersih dari lima tahun lepas?*	**1**	**2**	**3**	**4**	**5**
Indicator: Safety Nets *Penunjuk: Jaring Keselamatan* **Sub-indicator:** Formal or informal financial sources to withstand liquidity crises *Sub-penunjuk: Sumber kewangan formal atau tidak formal untuk menghadapi krisis kecairan*					
Likert scale selection with the following statement: **(1) Not have, (2) Rarely have, (3) Occasionally have, (4) Frequently have, and (5) Consistently have** *Pemilihan skala likert dengan pernyataan berikut:* ***(1) Tidak ada, (2) Jarang ada, (3) Kadang-kadang ada, (4) Kerap ada, dan (5) Konsisten ada.***					
Did you have financial support from the government or informal financial support from your family in case of a crisis? *Adakah anda mendapat sokongan kewangan daripada kerajaan atau sokongan kewangan tidak rasmi daripada keluarga anda sekiranya berlaku krisis?*	**1**	**2**	**3**	**4**	**5**

Criteria 15: Value Creation *Kriteria 15: Penciptaan Nilai*
Indicator: Fiscal Commitment *Kriteria 15: Penciptaan Nilai* **Sub-indicator:** local taxes and Zakat *Sub-penunjuk: Cukai tempatan dan Zakat*
Likert scale selection with the following statement: **(1) Not pay and contribute, (2) Rarely pay and contribute, (3) Occasionally pay and contribute, (4) Frequently pay and contribute, and (5) Consistently pay and contribute** *Pemilihan skala likert dengan pernyataan berikut:* ***(1) Tidak membayar dan menyumbang, (2) Jarang membayar dan menyumbang, (3) Kadang-kadang membayar dan menyumbang, (4) Kerap membayar dan menyumbang, dan (5) Membayar dan menyumbang secara konsisten***

Did you pay the local agriculture land tax and contribute to Zakat on paddy? *Adakah anda membayar cukai tanah pertanian tempatan dan menyumbang kepada ZAKAT Padi?*	**1**	**2**	**3**	**4**	**5**

Social Dimension *Dimensi Sosial*					
Element: Decent livelihoods of farmers *Elemen: Penghidupan petani yang layak* **Criteria 16:** Quality of Life *Kriteria 16: Kualiti Hidup*					
Indicator: Right to Quality of Life *Penunjuk: Hak untuk Kualiti Hidup* **Sub-indicator:** Wellbeing status *Sub-penunjuk: Status kesejahteraan*					
Likert scale of satisfaction with the following statement: **(1) Not satisfied, (2) Rarely satisfied, (3) Occasionally satisfied, (4) Frequently satisfied, and (5) Consistently satisfied** *Skala likert kepuasan dengan pernyataan berikut:* ***(1) Tidak berpuas hati, (2) Jarang berpuas hati, (3) Kadang-kadang berpuas hati, (4) Kerap berpuas hati, dan (5) Berpuas hati secara konsisten***					
What is the level of satisfaction with the following items: current standard of living, personal health, life achievement, personal relationship with family, personal safety on the farm, community connectedness, future security, and spiritual/religious activities? *Apakah tahap kepuasan terhadap perkara berikut: taraf hidup semasa, kesihatan diri, pencapaian hidup, hubungan peribadi dengan keluarga, keselamatan diri di ladang, keterkaitan komuniti, keselamatan masa depan dan aktiviti kerohanian/keagamaan?*	**1**	**2**	**3**	**4**	**5**

Criteria 17: Capacity Development *Kriteria 17: Pembangunan Kapasiti*					
Indicator: Capacity Development *Penunjuk: Pembangunan Kapasiti* **Sub-indicator:** Paddy Farmers' Capacity Level *Sub-penunjuk: Tahap Kapasiti Pesawah*					
Likert scale of ability with the following statement: **(1) Very low (2) Low, (3) Neutral, (4) High, (5) Very high** *Skala kebolehan likert dengan pernyataan berikut****: (1) Sangat rendah (2) Rendah, (3) Neutral, (4) Tinggi, (5) Sangat tinggi***					
What is your ability level to utilise resources, plan a business, and identify farming opportunities? *Apakah tahap keupayaan anda untuk menggunakan sumber, merancang perniagaan, dan mengenal pasti peluang pertanian?*	**1**	**2**	**3**	**4**	**5**

Criteria 18: Right to use land *Kriteria 18: Hak untuk menggunakan tanah*
Indicator: Land use rights

Penunjuk: Hak guna tanah **Sub-indicator:** Land ownership rights *Sub-penunjuk: Hak milik tanah*					
Likert scale selection with the following statement: **(1) Not have, (2) Rarely have, (3) Occasionally have, (4) Frequently have, and (5) Consistently have** *Pemilihan skala likert dengan pernyataan berikut**: (1) Tidak ada, (2) Jarang ada, (3) Kadang-kadang ada, (4) Kerap ada, dan (5) Konsisten ada.***					
Do you have legal ownership or a joint venture agreement with indigenous peoples, families, and other paddy farmer landowners on the land you cultivate paddy? *Adakah anda mempunyai pemilikan sah atau perjanjian usaha sama dengan orang bumiputera, keluarga, dan pemilik tanah pesawah lain di tanah yang anda mengusahakan padi?*	**1**	**2**	**3**	**4**	**5**

Element: Labour rights *Elemen: Hak pekerja* **Criteria 19:** Employment condition *Kriteria 19: Keadaan pekerjaan*					
Indicator: Employment relations *Penunjuk: Pekerjaan relations* **Sub-indicator:** Employment contract *Sub-penunjuk: Kontrak pekerjaan*					
Likert scale selection with the following statement **(1) Not have, (2) Rarely have, (3) Occasionally have, (4) Frequently have, and (5) Consistently have** *Pemilihan skala likert dengan pernyataan berikut**: (1) Tidak ada, (2) Jarang ada, (3) Kadang-kadang ada, (4) Kerap ada, dan (5) Konsisten ada.***					
Do you have a written or verbal agreement between employed workers? *Adakah anda mempunyai perjanjian bertulis atau secara lisan antara pekerja yang bekerja?*	**1**	**2**	**3**	**4**	**5**

Element: Human safety & health *Elemen: Keselamatan & kesihatan manusia* **Criteria 20:** Workplace safety *Kriteria 20: Keselamatan di tempat kerja*					
Indicator: Safety Instruction and First Aid *Penunjuk: Arahan Keselamatan dan pertolongan cemas* **Sub-indicator:** Safety Instruction and First Aid *Sub-penunjuk: Arahan Keselamatan dan pertolongan cemas*					
Likert scale selection with the following statement: **(1) Not conducted, (2) Rarely conducted, (3) Occasionally conducted, (4) Frequently conducted and (5) Consistently conducted** *Pemilihan skala likert dengan pernyataan berikut: **(1) Tidak dijalankan, (2) Jarang dijalankan, (3) Kadang-kadang dijalankan, (4) Kerap dijalankan dan (5) Dijalankan secara konsisten***					
Do you conduct the following activities: I. Read safety instructions and regularly brief workers or working household members before conducting farming activities. II. Have a first aid kit on the farm	**1**	**2**	**3**	**4**	**5**

<table>
<tr><td>III. Apply the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) procedure
IV. Know to contact emergency authorities in case an accident occurs
V. The first aid kit is constantly updated and accessible
Adakah anda mengamalkan aktiviti berikut:
I. Baca arahan keselamatan dan taklimat biasa kepada pekerja atau ahli rumah yang bekerja sebelum menjalankan aktiviti bercucuk tanam.
II. Mempunyai peti pertolongan cemas di ladang
III. Gunakan prosedur Pengenalpastian Bahaya, Penilaian Risiko dan Kawalan Risiko (HIRARC).
IV. Ketahui untuk menghubungi pihak berkuasa kecemasan sekiranya berlaku kemalangan
V. Peti pertolongan cemas sentiasa dikemas kini dan boleh diakses</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Indicator: Tools and equipment
Penunjuk: Alat dan peralatan
Sub-indicator: Tools and equipment
Penunjuk: Alat dan peralatan</td></tr>
<tr><td colspan="6">Likert scale selection with the following statement: (1) Not conducted, (2) Rarely conducted, (3) Occasionally conducted, (4) Frequently conducted and (5) Consistently conducted
Pemilihan skala likert dengan pernyataan berikut: (1) Tidak dijalankan, (2) Jarang dijalankan, (3) Kadang-kadang dijalankan, (4) Kerap dijalankan dan (5) Dijalankan secara konsisten</td></tr>
<tr><td>Are your farm tools and equipment properly working, calibrated, and properly stored?
Adakah alatan dan peralatan ladang anda berfungsi, ditentukur dan disimpan dengan betul?</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Indicator: Training of pesticide applicators
Penunjuk: Latihan aplikator racun perosak
Sub-indicator: Training of pesticide applicators
Sub-penunjuk: Latihan aplikator racun perosak</td></tr>
<tr><td colspan="6">Likert scale selection with the following statement (1) Not briefing, (2) Rarely briefing, (3) Occasionally briefing, (4) Frequently briefing and (5) Consistently briefing
Pemilihan skala likert dengan pernyataan berikut: (1) Tidak memberi taklimat, (2) Jarang memberi taklimat, (3) Taklimat sekali-sekala, (4) Taklimat kerap dan (5) Taklimat secara konsisten</td></tr>
<tr><td>Do you regularly brief workers or household members who are working before conducting pesticide activities?
Adakah anda kerap memberi taklimat kepada pekerja atau ahli rumah yang bekerja sebelum menjalankan aktiviti racun perosak?</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Indicator: Personal protective equipment (PPE)
Penunjuk: Alat pelindung diri (PPE)
Sub-indicator: Personal protective equipment (PPE)
Sub-penunjuk: Alat pelindung diri (PPE)</td></tr>
</table>

Likert scale selection with the following statement: **(1) Not conducted, (2) Rarely conducted, (3) Occasionally conducted, (4) Frequently conducted and (5) Consistently conducted** *Pemilihan skala likert dengan pernyataan berikut:* ***(1) Tidak dijalankan, (2) Jarang dijalankan, (3) Kadang-kadang dijalankan, (4) Kerap dijalankan dan (5) Dijalankan secara konsisten***					
Do you and your worker use gloves, masks, long-sleeved shirts, long-trouser legs, boots, and eye protection during mixing and application? *Adakah anda dan pekerja anda menggunakan sarung tangan, topeng, baju lengan panjang, kaki seluar panjang, but dan pelindung mata semasa membancuh dan menggunakan?*	**1**	**2**	**3**	**4**	**5**
Indicator: Washing and changing *Penunjuk: Mencuci dan menukar* **Sub-indicator:** Washing and changing places *Penunjuk: Tempat mencuci dan menukar*					
Likert scale selection with the following statement: **(1) Not have, (2) Rarely have, (3) Occasionally have, (4) Frequently have, and (5) Consistently have** *Pemilihan skala likert dengan pernyataan berikut****: (1) Tidak ada, (2) Jarang ada, (3) Kadang-kadang ada, (4) Kerap ada, dan (5) Konsisten ada.***					
Do you have designated areas for washing PEE, bathing, and changing available and separated from the main housing? *Adakah anda mempunyai kawasan yang ditetapkan untuk mencuci PEE, mandi, dan menukar pakaian yang tersedia dan dipisahkan dari perumahan utama?*	**1**	**2**	**3**	**4**	**5**
Indicator: Applicator restrictions *Penunjuk: Pengguna yang tidak dibenarkan* **Sub-indicator:** Applicator restrictions *Penunjuk: Pengguna yang tidak dibenarkan*					
Likert scale selection with the following statement **(1) Not prevent, (2) Rarely prevent, (3) Occasionally prevent, (4) Frequently prevent, and (5) Consistently prevent** *Pemilihan skala likert dengan pernyataan berikut:* ***(1) Tidak mencegah, (2) Jarang mencegah, (3) Kadang-kadang mencegah, (4) Kerap mencegah, dan (5) Mencegah secara konsisten***					
Do you prevent pregnant women, persons below 18 years old, and persons suffering from the disease to conduct pesticide activity? *Adakah anda meminta wanita hamil, mereka yang berumur di bawah 18 tahun dan mereka yang menghidap penyakit untuk menjalankan aktiviti racun perosak?*	**1**	**2**	**3**	**4**	**5**
Indicator: Re-entry time *Penunjuk: Masa masuk semula* **Sub-indicator:** Re-entry time *Penunjuk: Masa masuk semula*					
Likert scale selection with the following statement: **(1) Not followed, (2) Rarely followed, (3) Occasionally followed, (4) Frequently followed, and (5) Consistently followed** *Pemilihan skala likert dengan pernyataan berikut:* ***(1) Tidak diikuti, (2) Jarang diikuti, (3) Kadang-kadang diikuti, (4) Kerap diikuti, dan (5) Diikuti secara konsisten***					

Do you follow the re-entry time after applying pesticide on your paddy field? *Adakah anda mengikuti masa kemasukan semula selepas menggunakan racun perosak pada sawah padi anda?*	**1**	**2**	**3**	**4**	**5**
END OF QUESTIONS *SOAL SELIDIK TAMAT*					

APPENDIX 12A

Letter of Permission Conducted Research

www.uitm.edu.my

UNIVERSITI TEKNOLOGI MARA | Fakulti Perladangan dan Agroteknologi

Tarikh: 18 hb April 2025

Mario Bin Valeriano
Pengarah IADA Barat Laut Selangor
Kawasan Pembangunan Pertanian Bersepadu (IADA),
Barat Laut Selangor, Kompleks Pejabat IADA,
45000 Kuala Selangor,
Selangor Darul Ehsan
Email: mario@kpkm.gov.my
Tel: 03-3289 1411

السلام عليكم ورحمة الله وبركاته

Tuan,

JEMPUTAN KERJASAMA PENYELIDIKAN DI ANTARA UNIVERSITI TEKNOLOGI MARA - UiTM DAN IADA BARAT LAUT SELANGOR

Dengan hormatnya saya merujuk kepada perkara di atas.

2. Sukacitanya dimaklumkan pihak UiTM ingin menjemput **IADA BARAT LAUT SELANGOR** untuk mengadakan **KERJASAMA PROJEK PENYELIDIKAN KELESTARIAN TANAMAN PADI** di Barat Laut Selangor bertajuk ***"Penilaian Amalan Kelestarian dalam Kalangan Pesawah di Skim Pengairan IADA Barat Laut Selangor"*** kepada Kementerian Ekonomi Malaysia yang maklumatnya boleh didapati secara lebih terperinci di pautan *https://ekonomi.gov.my/sites/default/files/2025-03/POSTER-PERMOHONAN-KJP-TAHUN-2025-06032025.pdf*.

3. Objektif utama projek penyelidikan ini adalah untuk menilai amalan kelestarian di kalangan pesawah IADA Barat Laut Selangor. Kami percaya dengan kepakaran pihak tuan di dalam aspek pengurusan penanaman padi di Barat laut Selangor ini akan banyak membantu pihak UiTM untuk mendapatkan data kajian yang bermakna bagi memberikan impak kepada kejayaan projek penyelidikan ini. Seorang pelajar pascasiswazah UiTM dan seorang penolong pengawai pertanian IADA akan dikhususkan untuk projek penyelidikan ini.

4. Sehubungan dengan itu, pihak UiTM melalui **FAKULTI PERLADANGAN DAN AGROTEKNOLOGI** ingin menjemput **Kawasan Pembangunan Pertanian Bersepadu (IADA), Barat Laut Selangor** melalui pegawainya **iaitu Ts. Mohammad Zuhairi Bin Ali Penolong Pegawai Pertanian Kawasan Pembangunan Pertanian Bersepadu (IADA)** bekerjasama dengan pihak UiTM untuk menjayakan program penyelidikan ini. Sebarang pertanyaan berkenaan program ini bolehlah berhubung dengan Prof. Madya Dr. Alawi bin Sulaiman di talian (

Sekian, terima kasih.

"MALAYSIA MADANI"
"BERKHIDMAT UNTUK NEGARA"

PROF. MADYA Ts. DR. ALAWI HJ SULAIMAN
Pengarah
Pusat Kepimpinan Institusi
Institut Kepimpinan dan Pembangunan (ILD)
Universiti Teknologi MARA

PROF. MADYA DR. ALAWI BIN SULAIMAN
Pensyarah
Fakulti Perladangan dan Agroteknologi

s.k:

1. ***Ts. Mohammad Zuhairi Bin Ali***
   Penolong Pegawai Pertanian
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   Barat Laut Selangor, Kompleks Pejabat IADA,
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2. ***Mohmmad Shafie Bin Hairal Anam***
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   Universiti Teknologi MARA Cawangan Melaka
   Kampus Jasin, 77300 Merlimau, Melaka
   Email: mohmmadshafie95@gmail.com, +

Letter of Approval Conducted Research

KAWASAN PEMBANGUNAN PERTANIAN BERSEPADU
INTEGRATED AGRICULTURE DEVELOPMENT AREA (IADA)
BARAT LAUT SELANGOR
Kompleks Pejabat IADA Barat Laut Selangor
45000 Kuala Selangor
Selangor

IADA BARAT LAUT SELANGOR
JELAPANG PADI SELANGOR

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Email: iadabls@kpkm.gov.my

Ruj. Tuan :
Ruj. Kami : PBLS.03/86.04 (94)
Tarikh : 25 April 2025

Prof. Madya Dr. Alawi bin Sulaiman
Fakulti Perladangan dan Agroteknologi
Universiti Teknologi MARA Cawangan Melaka
Kampus Jasin, 77300 Merlimau
MELAKA

Prof,

MAKLUM BALAS JEMPUTAN KERJASAMA PENYELIDIKAN DI ANTARA UNIVERSITI TEKNOLOGI MARA DAN IADA BARAT LAUT SELANGOR

Merujuk kepada surat jemputan daripada pihak Prof bertarikh 18 April 2024 berkenaan perkara di atas.

2. Sukacita dimaklumkan bahawa pihak IADA Barat Laut Selangor menyambut baik cadangan kerjasama penyelidikan bertajuk ***"Penilaian Amalan Kelestarian dalam Kalangan Pesawah di Skim Pengairan IADA Barat Laut Selangor"*** dan bersetuju untuk bekerjasama dengan pihak Universiti Teknologi MARA (UiTM) dalam menjayakan projek penyelidikan ini.

3. Sehubungan itu, pihak kami bersetuju untuk memberikan kerjasama penuh bagi menjayakan penyelidikan ini, termasuk dari aspek penempatan seorang penolong pegawai pertanian IADA untuk membantu pelaksanaan kajian di lapangan bersama pelajar pascasiswazah UiTM yang terlibat.

4. Pihak IADA juga berpandangan bahawa dapatan kajian ini amat berpotensi untuk dimanfaatkan dalam meningkatkan lagi tahap kecekapan, keberkesanan, dan kelestarian pesawah di kawasan IADA Barat Laut Selangor, seterusnya memberi impak positif terhadap pembangunan industri padi dan beras negara secara keseluruhan. Oleh itu, hasil penyelidikan ini akan diteliti dan berpotensi diaplikasikan dalam perancangan dan pelaksanaan program pembangunan pertanian di bawah seliaan kami.

5. Sebarang maklumat lanjut berkenaan pelaksanaan projek atau perkara teknikal boleh dibincangkan terus bersama pegawai yang dilantik pihak UiTM iaitu Ts. Mohammad Zuhairi bin Ali.

...2/-

(Sila catatkan rujukan Jabatan ini apabila berhubung)

PBLS.03/86.04 (94)

Sekian, terima kasih

"MALAYSIA MADANI"

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

(MARIO BIN VALERIANO)
Pengarah
IADA Barat Laut Selangor
mario@kpkm.gov.my

s.k

Setiausaha Bahagian
Kementerian Pertanian dan Keterjaminan Makanan
Bahagian Pembangunan Industri Padi
Aras 2, Wisma Tani
No. 28, Persiaran Perdana, Presint 4
Pusat Pentadbiran Kerajaan Persekutuan
62624 PUTRAJAYA

Informed Letter Conducted Research With Rice Farmer

UNIVERSITI TEKNOLOGI MARA
Fakulti Perladangan dan Agroteknologi

Rujukan Kami : 100-UiTMKJ(FPA.1/1)
Tarikh : 1447H 3 صفر
: 28 Julai 2025

KEPADA YANG BERKENAAN
(seperti dilampiran)

السلام عليكم ورحمة الله تعالى وبركاته

Tuan

MEMOHON KEBENARAN UNTUK MENDAPATKAN MAKLUMAT DAN DATA BAGI TUJUAN KAJIAN PENYELIDIKAN

NAMA PELAJAR	:	MOHMMAD SHAFIE BIN HAIRAL ANAM (011-31957328)
NO. PELAJAR	:	2022417228
PROGRAM	:	DOCTOR of PHILOSOPHY (Ph.D)
KOD PROGRAM	:	AT950
FAKULTI	:	PERLADANGAN DAN AGROTEKNOLOGI
TAJUK PENYELIDIKAN	:	*Development of a Comprehensive Sustainability Index for Rice Cultivation among Farmers in Malaysia based on Environmental, Social and Economic Dimensions*

Dengan segala hormatnya perkara di atas adalah dirujuk.

2. Dimaklumkan bahawa pelajar seperti nama di atas adalah pelajar dari Fakulti Perladangan dan Agroteknologi, Universiti Teknologi MARA, Cawangan Melaka, Kampus Jasin.

3. Pihak fakulti memohon jasa baik pihak tuan untuk memberikan kebenaran bagi pelajar ini untuk mendapatkan maklumat bagi tujuan kajian penyelidikan beliau. Sehubungan dengan itu pihak fakulti berharap pihak tuan dapat mempertimbangkan permohonan ini.

Segala kerjasama dan kelulusan daripada pihak tuan amatlah dihargai dan didahului dengan ucapan terima kasih.

Sekian.

اوسهاء تقوى، مليا

"MALAYSIA MADANI"
"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah

Ts. DR. SITI AMNI BINTI ISMAIL
Koordinator Siswazah

b.p. Dekan

s.k.
1. Prof. Madya Dr. Alawi bin Hj. Sulaiman (Penyelia Utama)
2. Ts. Mohammad Zuhairi Bin Ali (Penolong Pegawai Pertanian IADA)
3. Fail Pelajar

Pusat Pengajian Siswazah
Fakulti Perladangan dan Agroteknologi
Universiti Teknologi MARA
Cawangan Melaka, Kampus Jasin
77300 Merlimau, Melaka, MALAYSIA
Tel: (+606) 264 5190 / 5182 / 5170 / 5177

Rujukan Kami : 100-UiTMKJ(FPA.1/1)

SENARAI EDARAN

1. **Mohamad Hatta bin Ramli**
   Usahawan Padi Panchang Bedena,
   Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
   Komplex Pejabat IADA Barat Laut Selangor,
   45000 Kuala Selangor,
   Selangor Darul Ehsan
   Tel: 019-3467354

2. **Mohamad Azhar bin Markaban**
   Usahawan Padi Panchang Bedena,
   Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
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3. **Hasbullah bin Samsudin**
   Usahawan Padi Panchang Bedena,
   Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
   Komplex Pejabat IADA Barat Laut Selangor,
   45000 Kuala Selangor,
   Selangor Darul Ehsan
   Tel: 019 - 365 6918

4. **Salleh bin Kadeno**
   Usahawan Padi Panchang Bedena,
   Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
   Komplex Pejabat IADA Barat Laut Selangor,
   45000 Kuala Selangor,
   Selangor Darul Ehsan
   Tel: 019 - 348 6577

5. **Jainuri bin Mat Nor**
   Usahawan Padi Panchang Bedena,
   Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
   Komplex Pejabat IADA Barat Laut Selangor,
   45000 Kuala Selangor,
   Selangor Darul Ehsan
   Tel: 017 - 673 1196

6. **Zulhlmie bin Shafie**
   Usahawan Padi Bagan Terap,
   Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
   Komplex Pejabat IADA Barat Laut Selangor,
   45000 Kuala Selangor,
   Selangor Darul Ehsan
   Tel: 013 - 404 2115

7. **Mohd Firdaus bin Mohd Jelani**
   Usahawan Padi Bagan Terap,
   Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
   Komplex Pejabat IADA Barat Laut Selangor,
   45000 Kuala Selangor,
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8. **Ikhsan Fairus bin Roslan**
Usahawan Padi Bagan Terap,
Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
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Selangor Darul Ehsan
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9. **Imran bin Kasri**
Usahawan Padi Bagan Terap,
Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
45000 Kuala Selangor,
Selangor Darul Ehsan
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10. **Zulazrin bin Sane**
Usahawan Padi Bagan Terap,
Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
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11. **Mohamad Firdaus bin Napiah**
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Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
45000 Kuala Selangor,
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12. **Salim bin Hashim**
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13. **Md Saifol bin Saimin**
Usahawan Padi Sungai Panjang,
Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
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14. **Mohd Zamri bin Farijan**
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Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
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15. **Mohd Nizam bin Saari**
    Usahawan Padi Sungai Panjang,
    Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
    Komplex Pejabat IADA Barat Laut Selangor,
    45000 Kuala Selangor,
    Selangor Darul Ehsan
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16. **Mohd Solehudin bin Razali**
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    Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
    Komplex Pejabat IADA Barat Laut Selangor,
    45000 Kuala Selangor,
    Selangor Darul Ehsan
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17. **Muhammad Azzim bin Abdul Basir**
    Usahawan Padi Sungai Nipah,
    Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
    Komplex Pejabat IADA Barat Laut Selangor,
    45000 Kuala Selangor,
    Selangor Darul Ehsan
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18. **Muhammad Farhan bin Muhammed Tohid**
    Usahawan Padi Sungai Nipah,
    Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
    Komplex Pejabat IADA Barat Laut Selangor,
    45000 Kuala Selangor,
    Selangor Darul Ehsan
    Tel: 017 - 246 9903

19. **Muhammad Farhan bin Lahuri**
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    Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
    Komplex Pejabat IADA Barat Laut Selangor,
    45000 Kuala Selangor,
    Selangor Darul Ehsan
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20. **Asyraf Muashim bin Razali**
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    Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
    Komplex Pejabat IADA Barat Laut Selangor,
    45000 Kuala Selangor,
    Selangor Darul Ehsan
    Tel: 012 - 277 2835

21. **Mohd Azlan bin Abd Razak**
    Usahawan Padi Pasir Panjang,
    Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
    Komplex Pejabat IADA Barat Laut Selangor,
    45000 Kuala Selangor,
    Selangor Darul Ehsan
    Tel: 017 - 386 1304

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22. **Mohd. Shahrol bin Mohd Sharif**
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Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
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23. **Yahya bin Jali**
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Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
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Selangor Darul Ehsan
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24. **Mohd Roba'e bin Judi**
Usahawan Padi Pasir Panjang,
Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
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Selangor Darul Ehsan
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25. **Muhamad Hamka bin Mohd Roba'e**
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Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
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26. **Mohd Kamal bin Abdullah**
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Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
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27. **Mohd Shahrizal bin Mokhta**
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Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
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Selangor Darul Ehsan
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28. **Firdaus Haqimi bin Abdul Rashid**
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Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
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29. **Samudin bin Abdullah**
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Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
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Selangor Darul Ehsan
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30. **Muhammad Ghazali bin Mad Laman**
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Komplex Pejabat IADA Barat Laut Selangor,
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31. **Lee Eng Siong**
Usahawan Padi Sekinchan,
Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
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45000 Kuala Selangor,
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32. **Wang Voon Chong**
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Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
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33. **Tan Kian Kim**
Usahawan Padi Sekinchan,
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34. **Lee Kim Cheong**
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35. **Puah Kim Kuang**
Usahawan Padi Sekinchan,
Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
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36. **Sahrullizal bin Ehsan**
Usahawan Padi Sungai Burong,
Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
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37. **Mohamad Imran bin Idris**
Usahawan Padi Sungai Burong,
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38. **Iqbal**
Usahawan Padi Sungai Burong,
Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
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39. **Nazrul**
Usahawan Padi Sungai Burong,
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Komplex Pejabat IADA Barat Laut Selangor,
45000 Kuala Selangor,
Selangor Darul Ehsan
Tel: 017 - 620 5813

40. **Amin**
Usahawan Padi Sungai Burong,
Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
45000 Kuala Selangor,
Selangor Darul Ehsan
Tel: 012 - 972 1440

41. **Zainudin Bin Sudar**
Usahawan Padi Sawah Sempadan,
Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
45000 Kuala Selangor,
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Tel: 011 - 1080 7692

42. **Rosul bin Sirat**
Usahawan Padi Sawah Sempadan,
Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
45000 Kuala Selangor,
Selangor Darul Ehsan
Tel: 016 - 248 1946

Rujukan Kami : 100-UiTMKJ(FPA.1/1)

43. Fairuzzaini bin Toif
Usahawan Padi Sawah Sempadan,
Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
45000 Kuala Selangor,
Selangor Darul Ehsan
Tel: 019 - 367 6179

44. Muhammad Amar bin Kassim
Usahawan Padi Sawah Sempadan,
Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
45000 Kuala Selangor,
Selangor Darul Ehsan
Tel: 017 - 318 2744

45. Hasnol Balik Bini Zainuri
Usahawan Padi Sawah Sempadan,
Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
45000 Kuala Selangor,
Selangor Darul Ehsan
Tel: 019 - 346 9606

46. Johar Bin Amat Kassan
Usahawan Padi Sawah Sempadan,
Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor,
Komplex Pejabat IADA Barat Laut Selangor,
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APPENDIX 13A

Microsoft Excel Macro Dashboard Google Drive Link

**https://drive.google.com/drive/folders/1pzO6wgS9pr2OueDIcjZquZ   AvTQpQr
B?usp=sharing.**

APPENDIX 14A

Research Ethics Approval for Assessment with Rice Farmers

www.uitm.edu.my

UNIVERSITI TEKNOLOGI MARA

Pejabat
Timbalan Naib Canselor
(Penyelidikan dan Inovasi)

Reference : 600-TNCPI (5/1/6)
Our reference : REC/07/2024 (PG/MR/308)
Date : 17 محرم 1445H
23 July 2024

Mr Mohmmad Shafie Hairal Anam - 2022417228
(Supervisor: Assoc. Prof. Dr Alawi Hj Sulaiman)
Faculty of Plantation and Agrotechnology
UiTM Melaka Branch
Jasin Campus
77800 Merlimau
MELAKA

سلام عليكم ورحمة الله وبركاته and Greetings

Mr

APPROVAL LETTER - UiTM RESEARCH ETHICS COMMITTEE

Thank you for submitting your research proposal to the Research Ethics Committee (REC). After considering your application, the Committee approved your proposal titled "Development of a Comprehensive Sustainability Index for Rice Cultivation in Malaysia Based on Environmental, Social and Economic Dimensions" at Kampung Sungai Panjang, Sungai Besar, Selangor. Details of the approval are as follows:

Ref. number:	REC/07/2024 (PG/MR/308)
Approval Period:	23 July 2024 until 31 May 2025
Authorised personnel:	1. Mohmmad Shafie Hairal Anam 2. Assoc. Prof. Dr Alawi Hj Sulaiman 3. Assoc. Prof. Dr Abdul Kadir Othman 4. Dr Nabila Farhana Jamaludin

The UiTM Research Ethics Committee operates in accordance to the ICH Good Clinical Practice Guidelines, Malaysian Good Clinical Practice Guidelines and the Declaration of Helsinki. The approval of this project is conditional upon your continuing compliance with these guidelines and declaration.

We draw to your attention the requirement that a report on this research, must be submitted every 12 months from the date of the approval or on the completion of the project, whichever occurs first. Failure to submit reports will result in withdrawal of consent for the project to proceed. Amendments, if any, to the study documents are to be submitted to the REC for approval.

If you require further information, please contact the REC Secretariat at 03-55448069/03-55442794 or email at recsecretariat@uitm.edu.my.

اوسها، تقوى، موليا
"MALAYSIA MADANI"
"BERKHIDMAT UNTUK NEGARA"

Yours sincerely,

(EMERITUS PROFESSOR DATO' DR RAYMOND AZMAN ALI)
Chairman
UiTM Research Ethics Committee

c.c.: Deputy Rector (PJIM&A), UiTM Melaka Branch

Universiti Teknologi MARA
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Tel: (+603) 5544 2004/2255
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ISO 9001:2015 No. Sijil: 10120156

UiTM di hatiku

APPENDIX 15A

Normalisation Data Google Drive Link

https://drive.google.com/drive/folders/1hfQED5L8MP0Y8r8v3qx3u2As24pEYLub?usp=sharing.

APPENDIX 16A

Criteria and Criteria Aggregation Score Google Drive Link

https://drive.google.com/drive/folders/1mRSDobVB9Wt8wSjZCBbCxxnigVnTfT_l?usp=sharing.

APPENDIX 17A

Interview Expert Information

	Name	Designation	Expertise	Organisation
1	Assoc Prof. Dr. Lum Mok Sum	Assoc Prof	Plant Physiology; Plant Biochemistry and Biotechnology	Universiti Malaysia Sabah
2	Prof. Dr. Norsida Man	Professor	Agricultural Development & Agricultural Extension	Universiti Putra Malaysia
3	Dr. Elisa Azura	Senior Lecture	Rice Production, Integrated Nutrient Management, Greenhouse Gas Emission	Universiti Putra Malaysia
4	Dr. Nor Diana Binti Mohd Idris	Senior Lecture	Arts and Applied Arts: Built Environment (Human Aspect) (Vulnerability And Sustainability Livelihood)	Universiti Kebangsaan Malaysia
5	Dr. Mohd Shukri Bin Mat Ali @ Ibrahim	Agriculture Research Officer	Plat Product & Nutrition	Malaysian Agricultural Research and Development Institute
6	Dr Syahrin Suhaimee	Agriculture Research Officer	Household income, Farm Economics, Rice Supply Chain and Social capital	Malaysian Agricultural Research and Development Institute
7	Dr. Shahida binti Hashim	Agriculture Research Officer	Postharvest Technology, Agronomy	Malaysian Agricultural Research and Development Institute
8	Dr. Ts. Nurul Elma Binti Kordi	Senior Lecture	Public Transport, Construction, Project Management, Sustainability, Social Sustainability, Safety	Universiti Teknologi MARA
9	Puan Aini Waznati binti Lasuan	Agriculture Officer	Rice Production and Agriculture Extension	Integrated Agriculture Development Area
10	Tuan Muhammad	Agriculture	Rice Production and	Integrated

	Zuhairi bin Ali	Officer	Agriculture Extension	Agriculture Development Area
11	Assoc Professor Dr. Rina Fadhilah Binti Ismail	Assoc Prof	Sustainability, SDG, Environmental, ESG, Green Strategies, Risk Reporting, Corporate Governance, Corporate Disclosure, Financial Reporting, Firm Performance	Universiti Teknologi MARA
12	Dr Alia Binti Azmi	Senior Lecture	Environmental Justice, Sustainable Development, Forestry and Environmental Health	Universiti Teknologi MARA
13	Dr. Muhamad Zahid Bin Muhamad	Senior Lecture	Supply Chain, Agricultural Economics, Sustainable Management, Plantation Management	Universiti Teknologi MARA
14	Dr. Puvan A/L Paramisparam	Senior Lecture	Soil Science, Crop Production, Waste Management, Sustainable Agriculture, Agronomy, Statistical Analysis	Universiti Teknologi MARA
15	Dr. Selvakkumar A/L K N Vaiappuri	Senior Lecture	Agribusiness Management, Sustainable Agriculture and Agriculture Finance	Universiti Teknologi MARA
16	Dr. Faridah Binti Pardi	Senior Lecture	Economic Growth and Sustainable Development	Universiti Teknologi MARA
17	Dr. Rospidah Ghazali	Senior Lecture	Economics (economic development)	Universiti Kebangsaan Malaysia

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LIST OF PUBLICATIONS:

HAIRAL, A. M., Sulaiman, A., Othman, A. K., & Jamaludin, N. F. (2025). Review of Sustainability Criteria for Paddy Farming in Malaysia Based on Environmental, Economic and Social Dimensions. INTERNATIONAL JOURNAL OF RESEARCH, 9, 1344-1362.

Anam, M. H., Sulaiman, A., Othman, A. K., & Jamaludin, N. F. (2025). Sustainability criteria for rice farmer practices based on environmental, economic and social dimensions. In IOP Conference Series: Earth and Environmental Science (Vol. 1535, No. 1, p. 012017). IOP Publishing.

Hairal Anam, M. S., Sulaiman, A., Othman, A. K., & Jamaludin, N. F. (2024, September). Sustainability practices of palm oil mills in the FELDA Sahabat region. In IOP Conference Series: Earth and Environmental Science (Vol. 1397, No. 1, p. 012019). IOP Publishing.