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Paddy farmers' awareness and knowledge of agroforestry practices in Siburan, Sarawak

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Abstract

Rice is an important staple food and the main source of income and livelihood, especially for rural communities in Malaysia. However, the area under rice cultivation in Malaysia has decreased due to poor quality of rice fields due to low productivity and climate change. Agroforestry is a system that combines trees with crops or livestock. It not only counteracts the effects of climate change by increasing the resilience of agriculture, but also combats poverty, food security, and land degradation. The aim of this study was to determine the awareness and perception of rice farmers in Siburan, Sarawak, toward agroforestry. The data for the study were obtained through questionnaire-based interviews in Kampung Skuduk and Kampung Chupak. Statistical tests were used to analyze and compare the data. Farmers' knowledge of agroforestry practices was limited, especially among non-agroforestry practitioners. There is no significant income difference between agroforestry practitioners and non-agroforestry practitioners as agroforestry is practiced on a small scale and for household consumption as there are no commercial market opportunities for the products. Governmental or non-governmental organizations should organize educational activities on agroforestry to disseminate information on these practices appropriate to the education level and age group of the target farmers. Awareness raising and information dissemination activities are important as lack of awareness hinders the implementation of agroforestry, for example, through awareness campaigns and training programs on agroforestry. The results of this study will serve as a guide for the authority to plan measures to increase the knowledge and importance of the agroforestry sector and the implementation of agroforestry.

Plain Language Summary

This study focuses on rice farming in Malaysia, where climate change has negatively impacted rice production, a crucial livelihood for rural communities. The research

Abbreviations: RM, Ringgit Malaysia; WM, weighted mean.

aims to assess rice farmers' awareness and knowledge of agroforestry, a method that integrates trees and crops to enhance agricultural resilience against climate change. Surveys and interviews were conducted with farmers in Siburan, Sarawak, revealing that while agroforestry can help farmers adapt to climate changes, many are unaware of its benefits. Key findings show that even though some farmers practice agroforestry, most do so on a small scale and are self-taught, limiting its effectiveness. The study suggests that targeted educational programs are needed to improve farmers' understanding and implementation of agroforestry. This can help them better cope with the challenges posed by climate change, ensuring more sustainable and productive farming practices.

1 | INTRODUCTION

Rice is one of the most important crops in Malaysia, as rice is the staple food for most of the population (Firdaus et al., 2020). Malaysians consume 80 kg of rice per person annually, which costs an average of Ringgit Malaysia (RM) 44/month/household (Hua et al., 2024). This amount equates to approximately 14.45% of an individual's daily caloric intake, based on the caloric content of rice (approximately 130 calories per 100 grams of cooked rice) and average dietary patterns in Malaysia. Rice cultivation is the main source of income and livelihood especially for rural communities in Malaysia, where 40% of farmers are entirely dependent on rice cultivation (Firdaus et al., 2020). However, the area under rice cultivation in Malaysia has decreased from 700,000 ha in 2018 to 647,900 ha in 2021 (Statista Research Department, 2021). The poor quality of rice fields due to low productivity and climate change is one of the factors for the conversion of rice fields.

Globally, climate change has affected agricultural, economic, social, and environmental sustainability through the changing unpredictability of climate factors such as temperature, rainfall, soil moisture, floods, drought, and other natural disasters (Ulises et al., 2022). Rice production is highly dependent on climate, as most of the world's rice production is grown in regions where the temperature is already close to the optimum for rice production (Fahad et al., 2018). An increase in temperature could reduce rice yields by up to 40%, as heat stress impairs the ability of rice flowers to pollinate (Fahad et al., 2018). An increase of 1% in temperature is expected to cause a 3.44% decrease in rice yield during the current season, with a minor residual impact leading to an additional 0.03% yield decrease in the following season due to ongoing heat stress on the crop system.

Farmers in Vietnam, Indonesia, the Philippines, Myanmar, Laos, and Thailand who practice agroforestry in their rice fields have been able to counteract the effects of climate change such as flooding and drought (Wangpakapattanawong et al., 2017). In the Philippines, coconuts are planted along rice fields to stabilize the soil (Wangpakapattanawong et al., 2017). Agroforestry can be defined as a land-use system that combines trees and crops or livestock on the same land unit, either temporally or spatially (Atangana et al., 2013). However, in this study, we take a broader view, recognizing intercropping systems—even those without trees—as part of the agroforestry continuum. This inclusive approach acknowledges the transitional nature of farming systems and allows for a comprehensive analysis of practices that incorporate elements of agroecological diversity. While tree-based systems offer specific benefits, such as long-term ecological stability, annual crop intercropping systems can also contribute to improved soil health, pest management, and climate resilience, thereby aligning with many goals of agroforestry.

Agroforestry has numerous economic and environmental benefits that can help farmers adapt to rapidly changing weather patterns and combat climate change (Bogale & Bekele, 2023). In addition, when properly managed, agroforestry also makes a significant contribution to food access and income (Duffy et al., 2021). In Malaysia, agroforestry is not a new issue as it is one of the sectors that contribute to socioeconomic development, especially for rural communities. Agroforestry was identified in Malaysia's 3rd National Agricultural Plan as one of the strategic action plans to achieve higher profit margins and increase farm incomes (Ministry of Agriculture, Malaysia [MOA], 1999). Little research has been conducted on agroforestry in Malaysia. Local agroforestry research received little attention as the government focused on industry and the automotive sector, resulting in slow progress.

In Sarawak, agroforestry practices are often integrated into smallholder farming systems, combining rice cultivation with tree crops such as rubber, fruit trees, and oil palm. However, in rural areas like Siburan, the adoption of agroforestry remains limited due to barriers such as lack of technical knowledge, market access, and financial constraints (personal observations). Preliminary observations by us indicate that while some farmers in Siburan practice forms of traditional

intercropping that align with agroforestry principles, awareness of formal agroforestry systems is minimal. This underscores the need for targeted interventions to promote agroforestry as a sustainable farming practice in the region.

Kampung Skuduk and Kampung Chupak are the main paddy-growing areas in Sarawak with an area of about 200 ha where paddy is grown twice a year. Although agroforestry in rice cultivation is practiced in many Southeast Asian countries such as Vietnam, Indonesia, the Philippines, Myanmar, Laos, and Thailand to mitigate climate change (Wangpakapattanawong et al., 2017), no agroforestry activities have been documented in the paddy fields in Kampung Skuduk and Kampung Chupak. While agroforestry has been recognized as a sustainable land-use practice in Malaysia, its adoption hinges on farmers' understanding of its principles and benefits. Existing literature has explored farmers' perceptions and willingness to adopt agroforestry practices, but there remains a critical gap in examining the depth and accuracy of their knowledge. This study addresses this gap by investigating how farmers' knowledge of agroforestry practices influences conservation behaviors and informs policy design. Understanding this relationship is essential for designing effective training programs and crafting policies that support sustainable agricultural practices. Therefore, the objective of this study was to determine the level of awareness and knowledge of rice farmers on agroforestry practices and their benefits in Kampung Skuduk and Kampung Chupak Siburan, Sarawak. Hence, we articulated the research questions derived from the stated objective. These research questions are as follows:

1. What is the level of awareness and knowledge of rice farmers in Kampung Skuduk and Kampung Chupak, Siburan, Sarawak, regarding agroforestry practices?
2. What benefits of agroforestry practices are recognized by rice farmers in Kampung Skuduk and Kampung Chupak, Siburan, Sarawak?

Core Ideas

- Rice is an important staple food and the main source of income and livelihood, especially for rural communities in Malaysia, but the area under rice cultivation in Malaysia has decreased due to poor quality of rice fields due to low productivity and climate change.
- Climate change has affected agricultural, economic, social, and environmental sustainability through the changing unpredictability of climate factors such as temperature, rainfall, soil moisture, floods, drought and other natural processes and rice production is highly dependent on climate. Agroforestry is a system that combines trees with crops or livestock, offering significant potential benefits such as increased resilience to climate change, enhanced agricultural productivity, and improved livelihoods.
- It is important to provide farmers with information on agroforestry practices because agroforestry can help them adapt to the climate change crisis. However, before knowledge about agroforestry is disseminated, it is important to determine the level of farmers' knowledge to ensure successful implementation of agroforestry.
- Farmers' knowledge of agroforestry practices was limited, especially among non-agroforestry practitioners. Hence, the findings from this study indicate that, in the context of the study area, agroforestry practitioners do not experience significant income advantages compared to non-practitioners. This is likely due to the small-scale nature of agroforestry practices, which are primarily focused on household consumption rather than commercial production.

2 | MATERIALS AND METHODS

2.1 | Study area

This study was conducted in Kampung Skuduk and Kampung Chupak in the Siburan District, Serian Division. Kampung Skuduk and Kampung Chupak is one of the wet paddy cultivation areas in Sarawak where rice is cultivated twice a year and a successful pilot project for wet paddy cultivation (iM Sarawak "Wet Paddy Cultivation Program") (Kong, 2014). The most important economic activity for the local population in Kampung Skuduk and Kampung Chupak is rice cultivation, according to the Siburan agricultural officer (personal communication). According to Jabatan Pertanian Daerah Siburan (Siburan District Department of Agriculture), there are about 89 rice farmers registered for 2023, most of whom are the majority Bidayuh ethnic group and Christian.

2.2 | Data collection

Data were collected through a formal questionnaire survey and interviews with registered rice farmers in Siburan. To ensure the representativeness of our sample, we collaborated with the Jabatan Pertanian Daerah Siburan (Siburan District Department of Agriculture) to identify a diverse group of respondents. Participants for this study were selected using purposive sampling to ensure the inclusion of individuals

actively engaged in rice farming. This approach allowed us to focus on participants who could provide detailed insights into the practices, challenges, and knowledge associated with rice farming in the region. To achieve geographic and demographic diversity, we identified participants from different villages across the study area, considering factors such as age, farming experience, and land size.

The selection process aimed to capture a range of perspectives, ensuring representation of both small-scale and larger-scale farmers. Efforts were also made to balance educational levels within the sample by including participants with varying degrees of formal education. However, we acknowledge that the sample reflects the broader demographic trends of rice farmers in the region, where the majority tend to be older individuals. This age distribution aligns with regional statistics indicating that younger generations are less involved in traditional farming practices. The questionnaire contained open-ended questions that sought respondents' opinions and closed-ended questions that included a menu of response options. The 5-point Likert scale was used to assess respondents' knowledge, awareness, and perception. The scales used in this study are (1 = very aware, 2 = aware, 3 = not sure, 4 = not aware, and 5 = not aware at all) for knowledge and awareness.

The questionnaires consisted of seven sections: (i) General socio-demographic information of the respondents, (ii) general information on rice cultivation, (iii) respondents' perception of rice cultivation, (iv) awareness and knowledge on agroforestry practices, (v) respondents' awareness on the benefits of agroforestry, (vi) respondents' perception on agroforestry practices, and (vii) The challenges in adopting agroforestry practices. For this study, we categorized agroforestry practices to include both tree-based systems and annual crop intercropping systems. This inclusive categorization reflects the diverse agroecological strategies adopted by farmers in the study area. Farmers practicing tree-based agroforestry (e.g., rubber, fruit trees, or oil palm with rice) and non-tree-based intercropping (e.g., rice intercropped with maize or vegetables) were analyzed under the broader agroforestry framework. This approach allows us to capture the spectrum of agroecological practices and better understand their socioeconomic and environmental implications. The decision to stop conducting interviews was guided by the principle of data saturation. Data saturation occurs when no new themes, patterns, or significant insights emerge from additional interviews, indicating that further data collection is unlikely to contribute substantially to the research findings. In this study, saturation was reached after conducting approximately 43 interviews with paddy farmers. After the interview, the paddy field of the respondent agroforestry practitioners was visited to verify the information provided by the agroforestry practitioners and to determine the type of agroforestry practiced.

TABLE 1 Weighted means for 5-ponit Likert scale adapted from Alonazi et al. (2019).

Weighted mean	Result
1–1.79	Strongly agree
1.8–2.59	Agree
2.60–3.39	Neutral
3.40–4.19	Disagree
4.20–5	Strongly disagree

2.3 | Data analysis

The data obtained from the interview and the questionnaires were analyzed using the Statistical Package for the Social Sciences. An unpaired *t*-test was used to compare the data and find a significant difference between respondents practicing agroforestry and respondents not practicing agroforestry. Chi-square test of independence was used to determine the significant difference between agroforestry practitioners and non-agroforestry practitioners. Since farmers in the study area practice agroforestry on a small scale, agroforestry practitioners in this study are rice farmers who grow other crops near their rice field, and non-agroforestry practitioners are farmers who grow only rice in the field. The data for the Likert scale on knowledge and awareness were analyzed according to the method of Alonazi et al. (2019). The weighted means (WMs) were calculated for the Likert scales, from Strongly Agree = 1 to Strongly Disagree = 5 (Table 1), to determine the trend of the composite score (Alonazi et al., 2019). The weighted averages are calculated using the formula; Weighted mean = $\Sigma(w)n\ (x^{-})n/\Sigma(w)n$, where x^{-} is the mean value of the set of given data and w is the corresponding weight for each observation.

3 | RESULTS

3.1 | Socio-demographic patterns of respondents in the study area

Note that 42% of the respondents practiced agroforestry practices (agroforestry practitioners), while 58% did not practice agroforestry (non-agroforestry practitioners). Most of the respondents belonged to the Bidayuh ethnic group (77%) and practiced Christianity (98%). Other demographic characteristics of the respondents included most males (63%), individuals above 65 years of age (49%), and those with secondary education (37%). Most respondents had extensive experience in rice farming, with 74% having over 21 years of farming experience. Regarding income, 67% of respondents earned less than RM 1300/month, which reflects the economic challenges faced by many subsistence farmers in the study area. Although RM 1300 is not an official poverty

FIGURE 1 Examples of agricultural practices observed in Kampung Skuduk and Kampung Chupak, including and intercropping systems (e.g., maize-paddy [a] and vegetables-paddy [b] combinations) and agroforestry systems (e.g., palm oil cultivation adjacent to rice paddy [c]) and palm oil cultivation adjacent to rice paddy (d).

line, it was selected as a cutoff to represent the lower-income group based on local economic conditions. There were no significant differences between agroforestry practitioners and non-practitioners in terms of ethnicity, religion, gender, age, marital status, education level, farming experience, or income (see Table 2).

3.2 | The types of agroforestry practices practiced by the agroforestry practitioners in the study areas

During the field visit, we found that most respondents engaged in two distinct practices: annual crop intercropping and agroforestry. Annual crop intercropping included combinations such as rice with maize (*Zea mays*) (Figure 1a) and rice with vegetables (Figure 1b). Agroforestry practices, which involve the integration of trees with crops or livestock, included examples such as the cultivation of palm oil opposite rice paddies (Figure 1c) and rubber intercropped with local fruit trees such as rose apples (*Syzygium jambos*) or pineapples (*Ananas comosus*).

3.3 | Agroforestry practitioners and non-agroforestry practitioners in study areas

Most agroforestry practitioners were self-taught in their knowledge of agroforestry practices, followed by influences or teaching from the older generation and finally from friends, authorities, and the media (Figure 2). More than half of the agroforestry practitioners practice agroforestry for consumption or to produce additional food for the family (60%); only a few practices agroforestry for additional income (32%), and the rest practice agroforestry because there is available land or area for cultivation (8%). Some respondents reported practicing agroforestry primarily because they had available land, which they utilized to plant additional crops or trees. This suggests a land-use optimization strategy rather than a direct focus on consumption or profit. However, these practices may also reflect traditional forms of land management, such as shifting cultivation or maintaining biodiversity on unused land. The duration of agroforestry practice among respondents was categorized into three groups: "since started paddy cultivation" (more than 10 years), "lately" (0–2 years), and "a few years after paddy cultivation" (3–9 years). The majority (70%) reported practicing agroforestry since starting paddy cultivation. This was significantly higher than the 40% who began agroforestry lately and the 20% who adopted it a few years after starting paddy cultivation (Figure 3). Land access factors such as lack of land or space and unsuitable land for cultivation are one of the main reasons given by respondents for not practicing agroforestry (47%) (Figure 4). The next most common reason for not practicing agroforestry is the lack of time, cost, and labor to simultaneously manage the paddy field and other integrated crops or livestock (Figure 4). Some of the non-agroforestry practitioners (13%) expressed concerns that integrating other crops or trees into their paddy fields could attract pests, potentially impacting their rice yields. Additionally, 80% of non-agroforestry practitioners indicated interest in adopting agroforestry if specific barriers, such as financial constraints, labor requirements, policy restrictions, or market access challenges, were addressed (Figure 5). These concerns highlight the perceived challenges associated with agroforestry practices, including potential increases in land and labor requirements, as well as fears of pest attraction.

TABLE 2 Sociodemographic and socioeconomic of respondents in Kampung Skuduk and Kampung Chupak, Siburan, Sarawak.

Variables	Number of respondents (%)	Agroforestry 18 (42%)	Non-agroforestry 25 (58%)	*t*-value	*p*-value
Gender					
Female	16 (37%)	7 (39%)	9 (36%)	−0.87	0.4768
Male	27 (63%)	11 (61%)	16 (64%)		
Age					
35–44	1 (2%)	1 (6%)	–	−0.58	0.5805
45–54	10 (23%)	3 (17%)	7 (28%)		
55–64	11 (26%)	4 (22%)	7 (28%)		
≥65	21 (49%)	10 (56%)	11 (44%)		
Marital status					
Single	1 (2%)	1 (6%)	–	−0.26	0.8091
Married	39 (91%)	15 (83%)	24 (96%)		
Divorce/widow	3 (7%)	2 (11%)	1 (4%)		
Race					
Iban	4 (9%)	2 (11%)	2 (8%)	−0.31	0.7620
Bidayuh	33 (77%)	13 (72%)	20 (80%)		
Cina	4 (9%)	3 (17%)	1 (4%)		
Orang Ulu	1(2%)	–	1 (4%)		
Others	1(2%)	–	1 (4%)		
Religions					
Christian	42 (98%)	18 (100%)	24 (96%)	−0.24	0.8329
Islam	1 (2%)	–	1 (4%)		
Education					
No formal education	11 (26%)	3 (17%)	8 (32%)	−0.37	0.7323
Formal education	31 (72%)	14 (78%)	17 (68%)		
Higher education	1 (2%)	1 (6%)	–		
Status practice					
Full time	36 (84%)	17 (94%)	19 (76%)	−0.34	0.7665
Part time	7 (16%)	1 (6%)	6 (24%)		
Income					
Less than RM 1300/month	36(84%)	16 (89%)	20 (80%)	−0.29	0.7837
RM 1300–RM 1400/month	5 (12%)	–	5 (20%)		
RM 1401–RM 1700/month	1 (2%)	1 (6%)	–		
More than RM 1701/month	1 (2%)	1 (6%)	–		
Experience in rice farming					
5–10 Years	6 (14%)	2 (11%)	4 (16%)	−0.35	0.7431
11–20 Years	5 (12%)	4 (22%)	1 (4%)		
≥21 Years	32 (74%)	12 (67%)	20 (80%)		

Note: The number of respondents was 43. An unpaired *t*-test was used to compare the difference between agroforestry practitioners and non-agroforestry practitioners. Significant level is at $p < 0.05$.

Abbreviation: RM, Ringgit Malaysia.

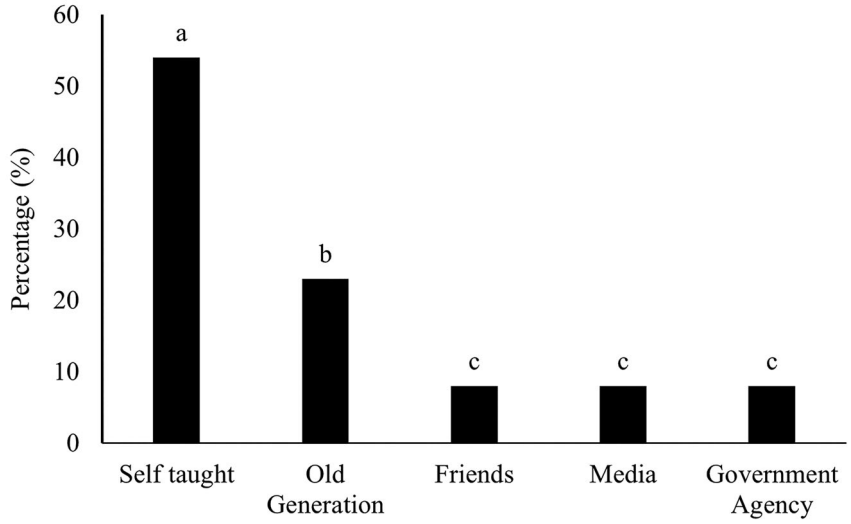

FIGURE 2 The source of agroforestry influences or knowledge among the agroforestry practitioners in the study area. Means with the same letter are not significantly different.

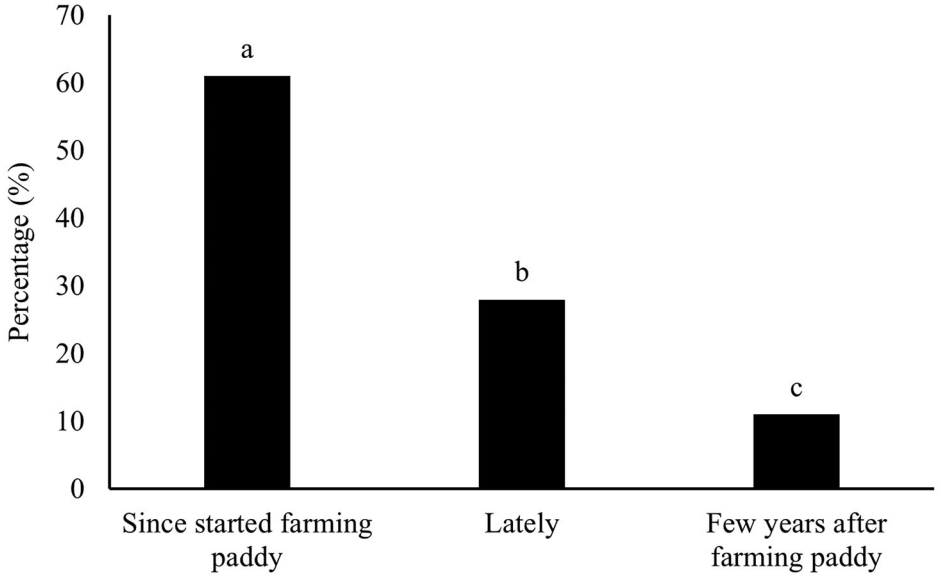

FIGURE 3 Duration of agroforestry practice among respondents categorized by years of experience (since started paddy cultivation = more than 10 years, lately = 0–2 years, few year = 3–9 years. Means with the same letter are not significantly different.

3.4 | Awareness and knowledge about agroforestry practices and their benefits among agroforestry practitioners and non-agroforestry practitioners in the study areas

Table 3 demonstrates that agroforestry practitioners were significantly more likely to have heard of the term "agroforestry" compared to non-practitioners. Specifically, 61% of agroforestry practitioners reported familiarity with the term, while only 24% of non-practitioners had heard of it. This significant difference underscores the critical role that awareness and exposure play in the adoption of agroforestry practices. However, it is worth noting that even among agroforestry practitioners, 39% had never encountered the term, suggesting that some farmers may be practicing agroforestry without a formal understanding of the concept.

Based on the WM of the Likert scale, non-agroforestry practitioners demonstrated measurably less knowledge about agroforestry compared to agroforestry practitioners and had less awareness of its benefits (Table 4). However, when examining specific benefits of agroforestry, no significant differences were observed between practitioners and non-practitioners in many areas, except for knowledge about pest reduction benefits ($X^2 = 6.344$, $p = 0.012$). This indicates that while non-practitioners perceive themselves as having less knowledge, there is overlap in understanding some specific benefits among both groups (Table 5). Respondents identified several key benefits of agroforestry

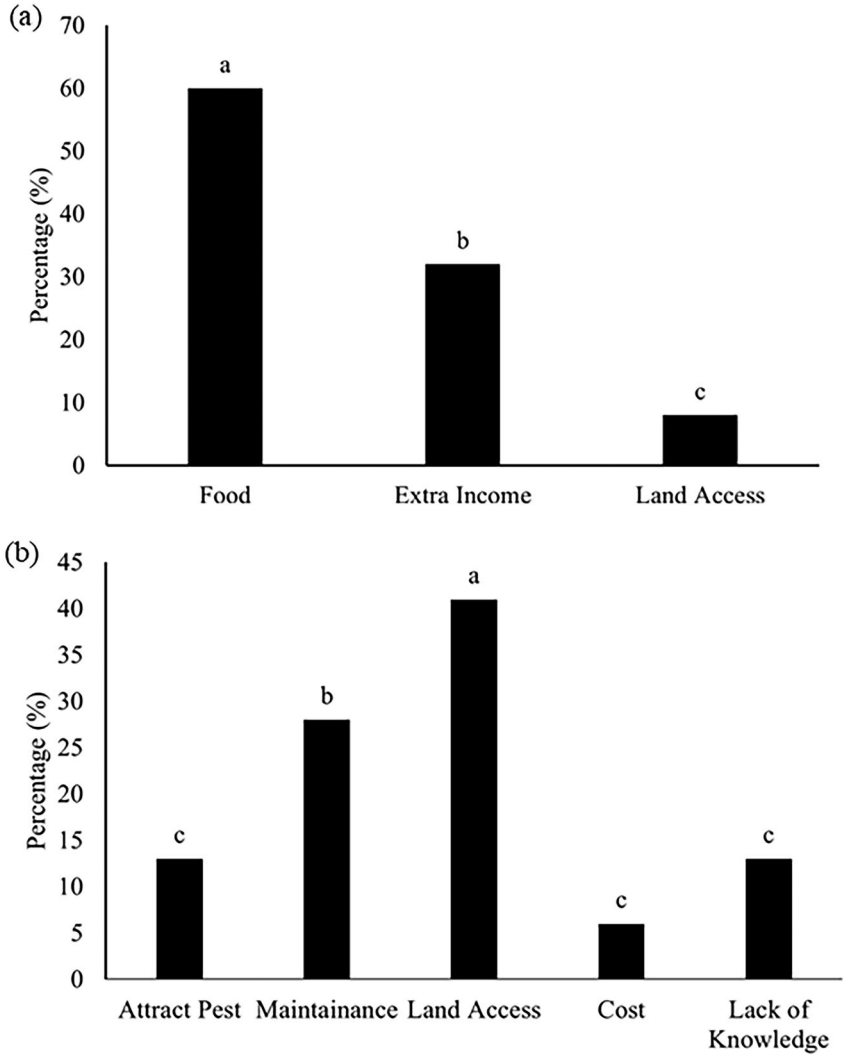

FIGURE 4 (a) The reasons agroforestry practitioners practicing agroforestry practices; (b) The reasons non-agroforestry practitioners did not practice agroforestry practices. Means with the same letter are not significantly different.

practices, including improved soil fertility (61% of agroforestry practitioners), reduced pest infestations (67%), and enhanced food security (83%). These benefits were recognized by both agroforestry practitioners and non-practitioners, though practitioners reported higher levels of awareness and understanding.

These findings underscore the potential for agroforestry to address critical challenges in rice farming systems, particularly those related to climate resilience and sustainable agricultural practices. Both agroforestry practitioners and non-agroforestry practitioners strongly agree that agroforestry should be practiced and would recommend it to others. This finding is surprising given the lower knowledge levels reported among non-agroforestry practitioners (Table 5). It suggests that positive perceptions of agroforestry may stem from general awareness or perceived social desirability rather than detailed understanding of its practices and benefits.

3.5 | Challenges and benefit adoption agroforestry among agroforestry practitioners and non-agroforestry practitioners in the study areas

The results in the Figure 4b show access to land, such as lack of land or space and unsuitable land for cultivation, is one of the main reasons respondents did not practice agroforestry. The common reason for not practicing agroforestry is the need for more time, cost, and labor to manage the paddy field and other integrated crops or livestock. Besides, the limited market opportunities to sell their produce is also one of the challenges in adopting agroforestry, which the respondents raised during the discussion. Some non-agroforestry practitioners expressed concerns that integrating other crops or trees into their paddy fields could attract pests, potentially impacting their rice yields.

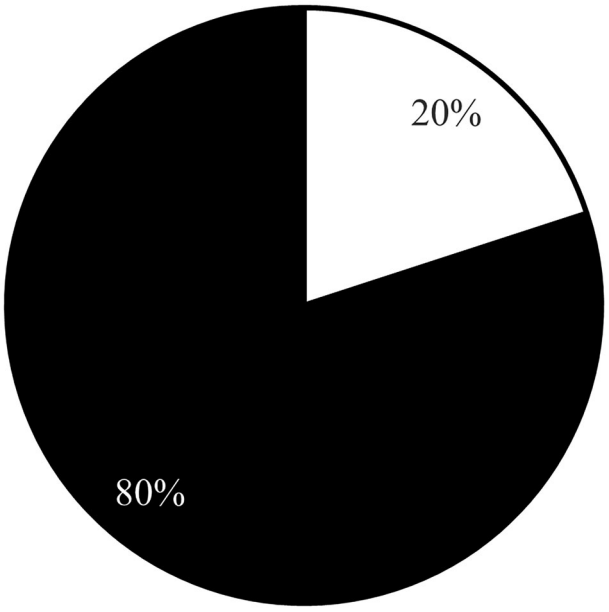

FIGURE 5 Interest in practicing agroforestry among non-practitioners, contingent upon the removal of key obstacles, including financial constraints, labor requirements, policy restrictions, and market access challenges.

4 | DISCUSSION

4.1 | Socio-demographic patterns of respondents in study areas and adoption of agroforestry practice

A study by Tangonyire and Akuriba (2020) in the Talensi District in the Upper East Region of Ghana found that access to land, gender dynamics, and financing are the socioeconomic factors influencing agroforestry adaptation in the study area. Furthermore, Sabastian et al. (2014) found that access to land is positively correlated with the adoption of agroforestry in Gunungkidul, Indonesia. Tangonyire and Akuriba (2020) suggest that younger farmers are more willing to adopt agroforestry practices because they see the long-term benefits of trees as an investment in the future and are not affected by the general perception that agroforestry is capital intensive but brings long-term returns. The level of education of farmers is said to have a positive impact on the adoption of agroforestry as a climate change adaptation strategy, as well-educated farmers can adapt to the latest technologies (Kebede & Coppock, 2015).

These results contradict the results of our study, which found no significant difference in any socioeconomic factors between agroforestry practitioners and non-agroforestry practitioners (Table 2). However, Place et al. (2003) also showed no influence of education on the adoption of agroforestry practices in Kenya. The study by Obeng and Weber (2014) in Ghana showed that age, education level, gender, and monthly income had an influence on the adoption of agroforestry practices. Furthermore, Mukundente et al. (2020) reported that age, marital status, gender, and income range are not associated with the adoption of agroforestry practices. There is no significant difference in the age group of agroforestry practitioners and non-agroforestry practitioners as most of the rice farmers in Kampung Skuduk and Kampung Chupak belong to the older generation, so there is no difference in the age group. Nevertheless, there is no significant difference in the education level of agroforestry practitioners and non-agroforestry practitioners in this study (Table 2), which could be due to the age group of the respondents, most of whom belong to the older generation.

Many studies have shown that agroforestry makes a significant contribution to income. For example, Rahman et al. (2016) in West Java, Indonesia, concluded that farmers who use agroforestry as an alternative cropping strategy can increase their average agricultural income. Farmers who practice agroforestry also have greater income potential because their land productivity increases (Singh et al., 2021). However, as shown in Table 2, there is no significant difference ($p < 0.05$) in the income of respondents between agroforestry practitioners and non-agroforestry practitioners in our study ($t = -0.29$, $p = 0.7837$). This is because most agroforestry practitioners engage in agroforestry consumption at home, so agroforestry does not contribute significantly to income generation. During the field visit, it was observed that agroforestry is not practiced on a large scale due to lack of market opportunities. Respondents stated that it is difficult for them to sell the harvest, even for their rice. In a study by Saliu et al. (2015) in the North Central Zone of Nigeria, it was found that lack of market opportunities for agroforestry products are the factors leading to farmers not continuing with agroforestry. The economic potential of agroforestry lies in its ability to diversify farm income through products such as fruits, timber, and fodder while reducing reliance on external inputs. However, our findings indicate that this potential remains underutilized due to limited market opportunities. Respondents reported challenges in accessing markets for agroforestry products, which often discourages adoption. Developing strong, localized markets and improving supply chain infrastructure are critical to ensuring the economic viability of agroforestry systems in the study area. Similarly, the lack of market opportunities for agroforestry products is one of the barriers to the introduction of the agroforestry system in the Czech Republic (Krčmářová et al., 2021). Therefore, the authorities should take the initiative and support farmers in marketing their products. This would enable farmers to participate in agroforestry on a larger scale to improve their socioeconomic situation and quality of life. Farmer participation in agroforestry practices could help solve current food supply and demand problems (Banyal et al., 2011).

TABLE 3 The respondents that heard of "*Agroforestry*" term and the respondents that never heard of "*Agroforestry*" term and their adaptation of agroforestry practices.

Description	Respondents	*t*-value	*p*-value
Heard of agroforestry (agroforestry practitioners)	11 (61%)	−6.12	**0.0036**
Heard of agroforestry (non-agroforestry practitioners)	6 (24%)		
Heard of agroforestry (agroforestry practitioners)	11 (61%)	4.90	**0.008**
Never heard of agroforestry (agroforestry practitioners)	7 (39%)		
Heard of agroforestry (agroforestry practitioners)	11 (61%)	9.80	**0.0006**
Never heard of agroforestry (non-agroforestry practitioners)	19 (76%)		

Note: An unpaired *t*-test was used to determine the significant difference between the respondents that heard the "Agro*forestry*" term and the respondents that never heard of "Agroforestry" on their adaptation of agroforestry practices. Significant level is at $p < 0.05$; the significant values were given in bold.

TABLE 4 Knowledge and perception toward agroforestry practices among agroforestry practitioners and non-agroforestry practitioners.

	Agroforestry practitioners		Non-agroforestry practitioners	
Statements	Weighted mean	Interpretation	Weighted mean	Interpretation
Knowledge on agroforestry practices	2.33	Good knowledge	3.88	Lack of knowledge
Awareness on the benefits of agroforestry practices	2.39	Aware	3.64	Not aware
Recommending agroforestry practice to acquaintances	1.50	Very likely to recommend	1.68	Very likely to recommend
Agroforestry practice must be practiced in agriculture	1.83	Agree	1.52	Strongly agree
More awareness activity on agroforestry must be organized	1.44	Very anticipating	1.36	Very anticipating
Workshop skills on agroforestry practices must be organized	1.56	Very anticipating	1.28	Very anticipating

Note: Weighted means for the Likert scale were calculated and the weighted mean tendency was determined (Refer Table 1).

TABLE 5 Agroforestry practitioners and non-agroforestry practitioners' awareness on the benefits agroforestry practices.

Benefits of agroforestry practices	Awareness	Agroforestry practitioners (%)	Non-agroforestry practitioners (%)	Chi-square value	*p*-value
Increase the yield	Yes	67	52	0.925	0.336
	No	33	48		
Improve the soil fertility	Yes	61	36	2.652	0.103
	No	39	64		
Reduce the pest attack	Yes	67	28	6.344	**0.012**
	No	33	72		
Provide/increase job opportunity	Yes	56	44	0.559	0.455
	No	44	56		
Improve food security	Yes	83	68	1.292	0.256
	No	17	32		
Reduce the impact of climate change	Yes	67	64	0.033	0.856
	No	33	36		
Reduce soil erosion risk	Yes	83	64	1.944	0.163
	No	17	36		

Note: A chi-square test of independence used to determine the significant difference in the awareness on agroforestry practices among agroforestry practitioners and non-agroforestry practitioners. Significant level is at $p < 0.05$; the significant value was given in bold.

4.2 | The awareness and knowledge on agroforestry practices and their benefits among the agroforestry practitioners and non-agroforestry practitioners in the study areas

A study by Musa et al. (2019) in Tawau found that rural communities are not aware of the term agroforestry even though they practice agroforestry in their daily lives. Our study found that agroforestry practitioners were significantly more likely to have heard the term agroforestry compared to non-practitioners (Table 3). While familiarity with the term is associated with adoption, this finding alone is not particularly meaningful without understanding the context of how practitioners gained this knowledge. For instance, exposure to training, extension programs, or community demonstrations may play a more critical role in fostering adoption. The lack of familiarity with the term among non-practitioners highlights the need for targeted awareness and capacity-building initiatives that not only introduce the concept of agroforestry but also provide practical knowledge about its implementation and benefits.

Agroforestry practitioners have a better knowledge of agroforestry practices and are more aware of the benefits of agroforestry than non-agroforestry practitioners (Table 4). Surprisingly, when asked about the benefits of agroforestry, there is no significant difference between agroforestry practitioners and non-agroforestry practitioners in terms of knowledge of most of the benefits, except for reducing pest infestation. Farmers' concerns about the challenges of agroforestry, such as its potential to attract pests, are valid and supported by some research (e.g., Altieri & Nicholls, 2004). While well-designed agroforestry systems can promote natural pest control and reduce infestations, inadequate implementation may result in unintended consequences, such as increased pest activity. Additionally, agroforestry often demands additional labor and land resources, which can act as barriers for smallholder farmers. Addressing these concerns through targeted education and practical support, including demonstrations of effective agroforestry systems, may help mitigate apprehension and promote adoption. The impact of agroforestry on pest pressures is highly context-dependent and varies across systems. While research often shows that agroforestry can promote natural pest control through increased biodiversity, certain systems may also experience pest challenges depending on the crops and management practices involved. In our survey, 67% of agroforestry practitioners reported no increase in pest issues associated with their practices. However, some non-agroforestry practitioners expressed concerns that agroforestry could attract pests, potentially affecting their paddy yields. These concerns highlight the need for targeted education and demonstration programs to address misconceptions and provide evidence-based information about agroforestry's pest management potential in specific contexts.

Although the knowledge of agroforestry practices among agroforestry practitioners is better than that of non-agroforestry practitioners, their knowledge of agroforestry is not sufficient as most of them are self-taught. Although there is a significant difference between agroforestry and non-agroforestry practitioners in their knowledge about the benefits of agroforestry, almost half (44%, Table 3) of agroforestry practitioners did not know about the benefits of this practice. The main sources of agroforestry influence among agroforestry practitioners are self-taught, followed by the influence of the older generation. Some agroforestry practitioners in this study may not fully implement agroforestry systems as described in scientific literature, but this does not necessarily indicate a lack of effective knowledge. For many, their practices are rooted in traditional knowledge passed down through generations, reflecting a deep understanding of local conditions and sustainable land-use strategies. While this knowledge may not always align with formal education or scientific frameworks, it provides sufficient, locally relevant insights to drive adoption in the study area. Future research should examine how traditional knowledge interacts with formal education to shape agroforestry practices and identify ways to integrate these knowledge systems to enhance outcomes. These points are confirmed by Musa et al. (2020) who further reported that poor dissemination of information on agroforestry systems and lack of awareness among communities in Tambunan Sabah, lead to their inability to fully implement the agroforestry system despite knowing the benefits of the agroforestry system.

Our study shows that friends, government agencies, and the media have the least influence on agroforestry practitioners. To understand the low adoption of agroforestry practices, we examined regional initiatives aimed at promoting agroforestry. Preliminary investigations indicate limited awareness campaigns and formal programs in the study area. While national programs supporting agroforestry exist, such as the Agroforestry Development and Biodiversity Conservation Program under the Ministry of Agriculture and Food Security, their reach and implementation in this region appear minimal. This program emphasizes integrating tree planting with agricultural systems to enhance biodiversity and improve farm productivity but has limited direct engagement with smallholder farmers in remote areas like Siburan. This gap underscores the need for tailored, localized initiatives to address specific barriers and leverage the region's traditional knowledge systems. This also indicates that few educational activities on agroforestry have been carried out. Interaction with different information providers, where the combination of different providers enriches farmers' knowledge because the different sources provide them with

different perspectives (Martini et al., 2017). Therefore, it is important to conduct awareness-raising activities with communities to share knowledge and information about agroforestry. Awareness-raising activities are important to increase knowledge about agroforestry practices. To ensure the success of awareness-raising activities, the age group and education level of the communities must be considered.

4.3 | Challenges of adopting agroforestry among the agroforestry practitioners and non-agroforestry practitioners in the study areas

Access to land remains a major obstacle to the introduction of agroforestry. Most of respondents cited the lack of available or suitable land for cultivation as the main reason for not practicing agroforestry (Figure 4b). This result emphasizes the structural challenges that many farmers face in accessing adequate resources to diversify their farming systems. Limited space and unsuitable land directly hinder the feasibility of integrating agroforestry practices, especially in regions where the land is overexploited or degraded. Chavula et al. (2023) reported that land access significantly influenced the likelihood of agroforestry adoption.

The second most frequently cited obstacle is the lack of time, financial resources and labor required to manage paddy fields, and the additional crops or livestock associated with agroforestry (Figure 4b). This illustrates the complexity of maintaining such integrated systems, as they require a significant amount of physical labor and economic investment (Ibrahim & Nabage, 2023). The dual management of paddy fields and agroforestry components often exceeds the capacity of smallholder farmers who already suffer from resource constraints. Mwase et al. (2015) stated high initial costs required for the establishment of agroforestry practices can demotivate the farmers to adopt agroforestry.

Interestingly, 13% of respondents expressed concerns about the potential environmental disadvantages of agroforestry, particularly the risk of attracting pests to their paddy fields (Figure 4b). This indicates a perceived trade-off between diversification and the stability of their primary crop yields. Farmers' concerns about the challenges of agroforestry, such as its potential to attract pests, are valid and supported by some research (e.g., Altieri & Nicholls, 2004). While well-designed agroforestry systems can promote natural pest control and reduce infestations, inadequate implementation may result in unintended consequences, such as increased pest activity. Additionally, agroforestry often demands additional labor and land resources, which can act as barriers for smallholder farmers.

These concerns may stem from a lack of knowledge about pest control strategies in agroforestry systems or previous negative experiences, emphasizing the need for targeted education and support to address such fears. Tranchina et al. (2024) highlighted that the availability or quality of knowledge or experience on technical and agronomic matters or knowledge diffusion necessary to implement or maintain agroforestry systems are the most encountered obstacles in agroforestry adoption. Meijer et al. (2014) also reported that the role of knowledge is one of the challenges in applying the evidence to agroforestry development programs. Musa et al. (2020) reported that poor dissemination of information on agroforestry systems and lack of awareness among communities in Tambunan Sabah lead to their inability to fully implement the agroforestry system despite knowing the benefits of the agroforestry system.

4.4 | Management implication of the study

Previous studies reported that the decision to adopt agroforestry is influenced by socio-demographic factors such as age group, education level, and so on. However, the results of this study show that the socio-demographic factors do not influence the adoption of agroforestry in the study area. Many studies have shown that agroforestry contributes to farmers' income (Desmiwati et al., 2021; Muthuri et al., 2023; Roslinda et al., 2023; Sudomo et al., 2023), but in this study agroforestry does not contribute to farmers' income because the products are grown only on a small scale for household consumption. Although 42% of the respondents practice agroforestry, they may not fully understand the concept as most of them are self-taught, and the influence of government agencies and media is very low.

Therefore, it is important to disseminate more information about agroforestry and raise awareness, especially among non-agroforestry practitioners. Respondents have gained a positive attitude toward agroforestry, which increases their willingness to adopt agroforestry and share relevant information about agroforestry with other farmers—a crucial step for these farmers to adopt this practice. The results of this study can serve as a guide for the authority to plan steps to improve the knowledge and relevance of the agroforestry sector and the implementation of agroforestry.

The authorities should assign officials with expertise in agroforestry or provide agroforestry extension services in the study area to enhance the agroforestry knowledge of farmers and facilitate their understanding of the concept of agroforestry. Since most of the farmers in the study area are elderly, it might be more difficult for them to learn and understand the practice only through theory or seminar. Therefore, the authorities should organize a training program or workshop that facilitates learning through practical demonstration. This includes the design and establishment

of agroforestry demonstration plots on farmers' land and in farmers' conditions managed by agroforestry practitioners. In addition, subsidies or incentives such as the provision of land and planting materials could help encourage farmers to adopt agroforestry practices. However, before implementing agroforestry programs with farmers, it is important to determine their level of knowledge to ensure the effectiveness of information dissemination and awareness-raising activities.

Although the role of knowledge, perceptions, and attitudes in the adoption of agroforestry has been documented, challenges remain in applying the evidence to agroforestry development programs (Meijer et al., 2014). Therefore, it is important that we conduct further research on farmers' knowledge, awareness, and perceptions of agroforestry to understand their behavior and decision-making factors. Only then can we ensure successful planning of agroforestry interventions for rice farmers that will help them improve their quality of life and sustain their livelihoods while protecting the environment.

4.5 | Limitation

This study provides a valid initial analysis of rice farmers' awareness, knowledge, and perception of agroforestry, but there are some limitations. We recognize that conducting the survey during the harvest season may have impacted the participation rate and potentially introduced bias into the results. This limitation, including its possible influence on the observed lack of economic differences between adopters and non-adopters, has been explicitly discussed in the manuscript. To mitigate this issue, we suggest that future studies consider scheduling data collection outside peak farming periods to ensure broader participation and minimize potential biases. Other limitation of our study is that the survey did not explicitly ask farmers about their needs for adopting agroforestry or their preferences for support programs. Future research should explore these aspects to ensure that recommendations are closely aligned with farmers' priorities and local realities. This would enable the development of more effective and farmer-centered initiatives to promote agroforestry. Future studies should include a larger sample size to obtain a more comprehensive picture of these variables on farmers' decisions and willingness to adopt agroforestry practices in their rice fields.

5 | CONCLUSION

To summarize, most of the non-agroforestry practitioners are interested in practicing agroforestry if there are no obstacles, and most of both agroforestry practitioners and non-agroforestry practitioners would like to recommend agroforestry to their acquaintances. The data obtained show that the non-agroforestry practitioners have a lack of knowledge compared to the agroforestry practitioners and are not aware of the benefits of agroforestry practice. Although agroforestry practitioners have good knowledge of agroforestry practice, they may not have adequate knowledge of the practice as most of them are self-taught. This is evidenced by the finding that some agroforestry practitioners have never heard the term agroforestry. The significant difference between agroforestry practitioners and non-agroforestry practitioners in terms of awareness of the term agroforestry shows that farmers who have been exposed to or heard about agroforestry are more inclined to practice or adopt agroforestry. This study provides new insights into agroforestry practices within the specific context of Kampung Skuduk and Kampung Chupak, Siburan, Sarawak. It uniquely focuses on understanding how traditional knowledge and formal education influence farmers' awareness, knowledge, and adoption of agroforestry. By examining the perceived benefits and barriers to agroforestry practices, such as financial constraints and market access challenges, this research offers actionable recommendations tailored to the local context. These findings contribute to the limited body of research on agroforestry in rural Sarawak and provide practical implications for policy and program development.

AUTHOR CONTRIBUTIONS

Jacklin Mathew: Conceptualization; data curation; formal analysis; investigation; software; validation; writing—original draft; writing—review and editing. **Daniel Ugih anak Echoh**: Conceptualization; data curation; formal analysis; methodology; project administration; writing—original draft; writing—review and editing. **Mohamad Hilmi Ibrahim**: Conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; project administration; resources; software; supervision; writing—original draft; writing—review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data on farmers' awareness and knowledge of agroforestry practices in Siburan, Sarawak, are available at Dryad Digital Repository (https://doi.org/10.5061/dryad.cz8w9gjfh).

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