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Impact of generational differences on rice farmer's perception and challenges in Champassak, Laos

Pei Yee Woh[1,2*], Phoutnapha Sengxayalath[3] and Khanh Van Pham Thi[4]

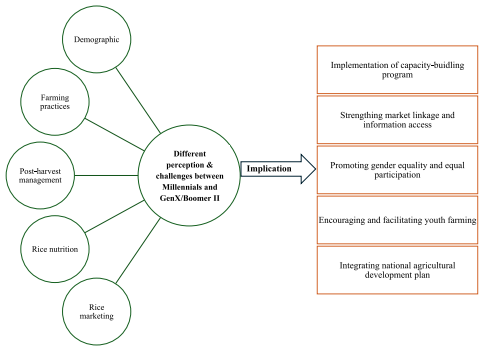
Abstract

Champassak province and particularly its' rice agriculture, plays a pivotal role in Laos' economy. However, there is a lack of research on how generational differences impact rice productivity, especially considering farmers' perceptions and challenges. This study aimed to explore farmer characteristics and perceptions regarding farming practices, post-harvest processes, rice nutrition, and key challenges affecting rice production in Champassak. To do so, we conducted face-to-face interviews with 100 rice farmers in Champassak in 2024 using a structured questionnaire format. Chi-square and regression analyses were employed to identify differences and factors influencing rice farming among Millennial (28–43 years), Gen X (44–59 years), and Boomer II (60–69 years) farmers. Key findings indicate significant generational differences in gender, rice farming experience, and farming practices, with Millennials comprising 45% and Gen X/Boomer II 55% of the sample. Post-harvest management preferences varied, with Millennials favoring rice storage and older farmers opting for direct selling. Millennials preferred rice varieties with market demand-driven traits, while older farmers valued drought tolerance. Despite improvements in rice quality, farmers faced challenges in securing optimal prices for their produce. Household size and irrigation based on soil moisture were inversely associated with increased rice yields. Overall, our findings offer critical insights into the rice farming community in Champassak and suggest policy interventions to improve farming practices and marketing strategies among rice farmers to support the long-term viability of rice farming in Laos.

Keywords Rice farming, Perception, Challenge, Millennial, Champassak Laos, Food security

*Correspondence:
Pei Yee Woh
peggywoh@gmail.com
Full list of author information is available at the end of the article

Graphical Abstract



Introduction

In recent years, The Association of Southeast Asian Nations (ASEAN) agricultural and food security economic framework has played a pivotal role in shaping agricultural policies and practices across Southeast Asia, including Laos [19, 32, 51]. This framework aims to enhance regional cooperation in ensuring food security, promoting sustainable agricultural practices, and improving the livelihoods of farmers. Such regional initiatives are crucial to many Southeast Asia countries, particularly Laos due to their reliance on rice farming as a primary economic activity and food source.

Laos is characterized by subsistence farming, where smallholders heavily rely on rice cultivation and livestock husbandry for sustenance [26]. Despite the significance of rice as a staple crop, many rural areas in Laos still struggle with rice insufficiency [45]. Rice serves as a key indicator of food security and poverty reduction in Laos [45]. To reduce food insecurity and poverty for low-income families, the Laos government has emphasized the importance of promoting sustainable agriculture and strives to meet the sustainable development goals to move away from Least Developed Countries status by 2026 [25]. According to the Laos Ministry of Agriculture and Forestry (MAF) statistics in 2012, rice is grown on more than 49% of cultivated land with more than 51% of rice paddy produced in central Laos (mainly in Savannakhet and Vientiane provinces and Vientiane Capital); about 27% in the southern provinces (such as Champassak and Saravanh); and 21% in the northern provinces (mainly in Sayaboury) [43]. The government aims to boost rice production for both domestic consumption and export, targeting 4.7 million tons in 2020 and 5.0 million tons in 2025 [22].

Champassak, with its fertile lands and strategic location along the Mekong River, is a key agricultural hub in Laos. However, the province faces unique challenges that are emblematic of broader regional issues addressed by the ASEAN framework, such as the need for sustainable farming practices, generational transitions in the farming workforce, and ensuring food security amidst environmental and economic pressures [43]. During the last decades, there has been a shift toward commercialization in rice farming, with the Chinese market for organic rice derived from Laos driving changes in farming practices toward high-yielding rice varieties and reduced chemical usage [8]. This shift is influenced by various factors, including the farmers' characteristics and perceptions of high-yield varieties, mechanization, and improved irrigation techniques [4, 8, 21, 35, 36, 45–47], as well as market demands and policy changes that have facilitated this shift [3, 28]. Therefore, understanding how different generations of farmers adapt to these changes is crucial for assessing the future of rice farming in the region.

Recent studies have increasingly recognized generational differences which play a pivotal role in rice farming [53, 56]. Older generations, such as Gen X and Boomer II, have traditionally engaged in subsistence farming, focusing on self-sufficiency and local food security. These farmers often rely on established practices and may be less inclined to adopt new technologies or commercial strategies. By contrast, younger farmers, particularly Millennials, are more open to innovation and market-oriented approaches. They are increasingly adopting sustainable practices and integrating technology into farming, which aligns with the broader trend toward commercial agriculture. These practices require different skills and resources, which can vary significantly across generations.

Although Champassak is one of the leading rice-producing provinces located along the Mekong River in southern Laos, the factors influencing rice production in

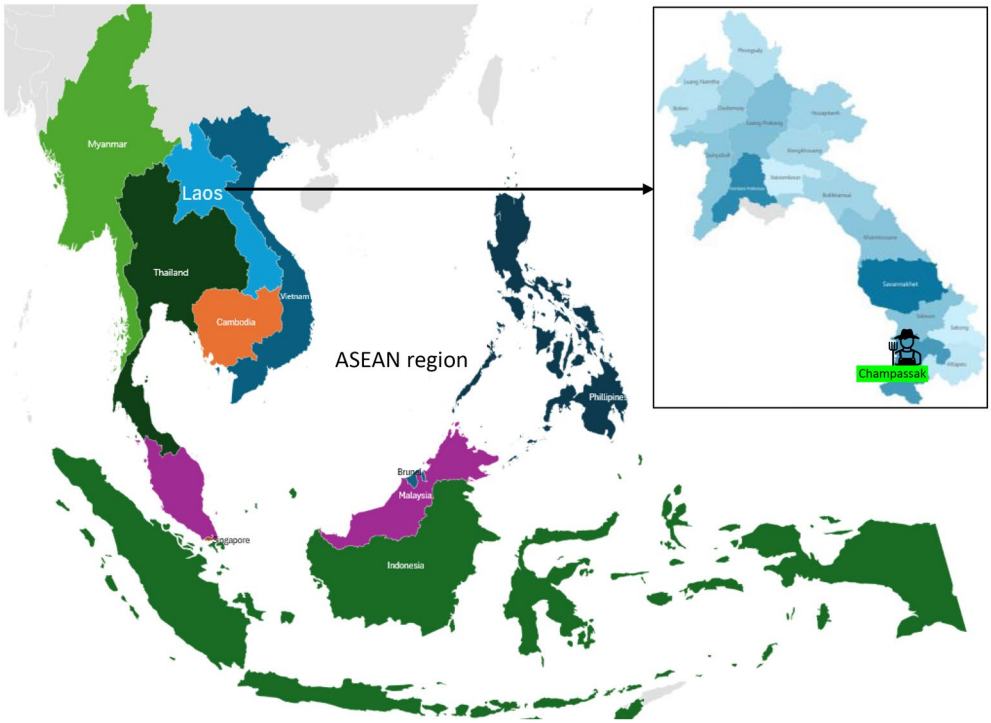


Fig. 1 Study location of Champassak province of Laos. This map is created in Excel powered by Bing

Champassak have not been well-studied. Therefore, our study seeks to answer the research gap concerning the impact of generational differences among Champassak rice farmer's farming practices and perceptions. Understanding these dynamics is essential for developing strategies that support sustainable agricultural development and rice farming in Laos.

Materials and methods

Research strategies and choices

This study employs a cross-sectional approach using questionnaire interviews to explore the impact of generational differences on rice farming challenges in Champassak province of Laos. The research strategy was chosen to allow for a fundamental understanding of the perspective of different generational cohorts, with the support of the 10th U.S.-ASEAN Women's Leadership Academy (WLA) for Young Southeast Asian Leaders Initiative (YSEALI) partnering with Women Education (WEDU), Agricultural Communities International (AGREA) Foundation, and Feminist Food Journal (FFJ) to combat food security issues in ASEAN [54, 55].

Study site

Champassak province of Laos was selected as our study site because it is one of the leading rice-producing provinces along the Mekong River. Champassak (14.84°N 105.75°E) has an area of 15,415 km^2 and is located in southwestern Laos, close to the border of Thailand and Cambodia (Fig. 1). Extensive lowland paddy production takes place in the Mekong River Valley and substantial coffee production on the Bolaven Plateau. Champassak has a tropical climate with two distinct seasons: the rainy season (May–October) and the dry season (November–April). The climatic conditions in Champassak province significantly influence rice farming practices. The rainy season, with an average temperature of 15–25 ℃ and rainfall ranging from 1000 to 3000 mm, supports rainfed rice farming, while the dry season, with temperatures of 37–40 ℃ and minimal rainfall of about 10 mm per month, necessitates irrigation strategies [28]. The average annual sunshine period of 6–8 h per day further impacts crop growth cycles. These environmental factors, combined with the province's fertile soil and abundant water supply from the Mekong River, create both opportunities and challenges for rice farmers [52]. Understanding these conditions is crucial for analyzing how different generations adapt their rice farming practices.

Time horizons and data collection

This study involved a questionnaire of rice farmers in Champassak. The recruitment process was initiated in January 2024 and questionnaires were completed by March 2024. Before conducting the survey, 10

enumerators (undergraduate students from Champassak University) received training to understand the study objective and sampling. During the process, the interviewers provided a brief introduction to the survey objectives and explained that the survey data would be used for research and requested their cooperation. All respondents provided informed consent. Codes were assigned to each respondent to maintain anonymity. The questionnaires were administered individually by face-to-face interviews in a sequential order, and generally completed in approximately 30–45 min. During data collection, respondents either read the questions themselves and enumerators insert the answers or enumerators read the questions to those respondents who have difficulties in literacy levels and eyesight.

Household and sample size

The sampling frame consisted of rice farmers identified by community farmer leaders in Champassak Province. In households where multiple members are involved in various job roles, we established a criterion for selecting the primary respondent to ensure data reliability. The primary respondent was identified as the household member who was most actively involved in decision-making related to rice farming activities. We measured household size as the total number of individuals living in a household. This measure was chosen, because it provides a straightforward indicator of the potential labor force available for rice farming activities, which is relevant to understanding generational differences in farming practices and challenges. The sample size was determined based on 5% absolute precision and 80% level of significance, and we employed a random sampling method to ensure representation across different age groups. Due to participant's literacy concerns and willingness to participate in the study, we identified 85 farmers who agreed to participate, and the response rate was 100%. Continuous efforts were made to follow up with non-respondents to enhance participation, and eventually, a total of 100 rice farmers participated in our study.

Study instrument (variable definition and nature of variable)

This study adopted a standard, objective-oriented, paper-based questionnaire along with a cover letter explaining the study purpose and the voluntary nature of participation. All questions were created in English, translated into Lao language and then independently translated back into English to ensure content validity. Some pictorial guides corresponding to the questions were provided in the questionnaire to ensure the accuracy of the responses. This study was approved by the Faculty of Agriculture and Forestry of Champassak University. The validated questionnaire included farmer's characteristics, farm and crop characteristics, farming practices, post-harvest experience, rice marketing and economies, rice quality, and perception of rice nutrition (Table 1). Most of the questions were closed-ended, which could be answered with a single-word answer ('yes' or 'no'), multiple choice options, and a five-point Likert-type scale ('1 = strongly disagree', '5 = strongly agree'). Open-ended questions were used to solicit the farmer's age (years), farming experience (years), working time (hours), family members (number), size of rice land (hectare), rice yield (tons), and rice sold (tons).

Data analysis

Data from the survey questionnaire were imported into Microsoft Excel through a double-entry system by two researchers PYW and PS to ensure data accuracy and precision. All raw data were merged in Microsoft Excel by farmer ID and imported into Statistical Package for Social Sciences (SPSS) for data analysis. Demographic and agronomic data were presented as frequency values. Continuous data, including farmer's age, household income, farming experience, and size of rice (harvested and sold), were collected and were later classified into different levels (Table 2). To analyze the difference between young and old farmers, we classified farmers' ages (continuous data) into three categorical variables corresponding to generational cohorts: Millennials (28–43 years), Gen X (44–59 years), and Boomer II (60–69 years) based on widely recognized generational definitions in demographic research [10, 53, 56]. Gen X and Boomer II were grouped into a single-category analysis. This decision was based on sample size considerations to increase the power of statistical analysis. Both generations have engaged in rice farming during similar economic and technological contexts, which may influence their approaches to agriculture in comparable ways. Additionally, combining these groups allowed us to focus on the broader generational gap between older farmers and the younger Millennial generation as centered in our study objective. Comparison of categorical variables between Millennials and Gen X/Boomer II was performed with χ^2 tests or Fisher's exact tests where appropriate. Mean scores for perception of rice nutrition were calculated and charts were drawn for visual interpretation. The association between the size of the rice harvest (dependent variable) and independent variables (household size and sustainable practices) was estimated using ORs and 95% CIs. Univariate analyses were performed, and selected variables were included in multivariable logistic regression analysis to simultaneously control for any confounding effects. Backward elimination was used to build the multivariable

Table 1 Questionnaire items and descriptions

Variable	Description and coding
Farmers characteristics	
Gender	1 = Male, 2 = Female
Age in years	Farmer's age in years
Age generation	1 = Millennials (28–43 years), 2 = Gen X (44–59 years), 3 = Boomer II (60–69 years)
Education level	1 = No school, 2 = Primary school, 3 = Secondary school, 4 = Tertiary/college/university
Monthly household income	Average of monthly household income level
Household member	Number of household members (count)
Job nature of household members	1 = Armed force, 2 = Clerical worker, 3 = Health professional, 4 = Service worker, 5 = Teaching professional
Farm and crop characteristics	
Rice farming experience	1 = ≤ 15 years, 2 = > 15 years
Previous job nature before rice farming	1 = Armed force, 2 = Clerical worker, 3 = Construction worker, 4 = Rice farmer, 5 = Health professional, 6 = Service worker, 7 = Student, 8 = Teaching professional
Working frequency in rice farm	1 = All time, 2 = Sometimes
Time spent on the rice farm	1 = 3–4 h, 2 = 5–8 h
Size of paddy land	1 = < 1.5 hectares, 2 = 1.5–3.0 hectares, 3 = > 3.0 hectares
Size of harvested rice	1 = < 5.0 tons, 2 = 5.0–10.0 tons, 3 = > 10 tons
Size of rice sold	1 = < 2.5 tons, 2 = 2.5–5.0 tons, 3 = > 5.0 tons
Ownership of paddy land	1 = Own, 2 = Rent
Family-owned other croplands	1 = Banana, 2 = Casava, 3 = Coffee, 4 = Lemon, 5 = Melon, 6 = Sugarcane, 7 = Vegetable, 8 = Mixed crop, 9 = None
Farming practices	
Sustainable practices	1 = Crop rotation, 2 = Composting or using organic manure, 3 = No practice
Water use practices	1 = Based on soil moisture, 2 = Daily, 3 = Every few days, 4 = Weekly
Soil water monitoring	1 = No monitoring, 2 = Simple water depth gauges, 3 = Visual inspection
Machinery farming practices	1 = Tractors only, 2 = Tractors and harvesters
Pesticide use practices	1 = Natural method, 2 = Organic pesticides
Fertilizer use practices	1 = Chemical, 2 = Chemical and organic, 3 = Manure from animals
Post-harvest experience	
Rice storage	1 = Selling rice immediately after harvest, 2 = Sun-drying and storing in sacks
Effect of storage on rice safety	1 = Improper storage conditions can encourage mold growth, 2 = Long storage times can lead to a loss of some nutrients
Effect of storage on rice nutrition	1 = Storage methods affect nutritional value, 2 = Not sure
Rice marketing and economies	
Changes in rice prices	1 = Prices have remained stable, 2 = Prices have increased, 3 = Prices have decreased
Channels for rice selling	1 = Cooperatives, 2 = Direct to consumers, 3 = Local markets, 4 = Middleman/brokers/wholesome, 5 = Rice mills
Challenges of rice marketing	1 = Competition from others, 2 = Finding reliable buyers, 3 = Getting the best price for rice, 4 = High transportation cost, producers, 5 = Inconsistent rice quality until difficult to reach a premium price, 6 = Lack of market information, 7 = Limited storage facilities, 8 = Other reasons
Rice quality	
Assessment of rice quality	1 = Odor test, 2 = Touch test, 3 = Visual inspection
Perception of the changes in rice quality	1 = Quality has improved, 2 = Quality has remained consistent, 3 = Not sure
Factors of choosing rice variety	1 = Drought tolerance, 2 = Grain quality, 3 = Market demand, 4 = Maturity time, 5 = Personal preference, 6 = Pest and disease resistance, 7 = Water requirements, 8 = Yield potential

Table 1 (continued)

Variable	Description and coding
Farmer's perception of rice nutrition	
Q1 Rice is good for health	1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree
Q2 Rice tastes good	
Q3 Rice contains lower fat compared to potatoes	
Q4 Compared to other carb-food (wheat, potato, maize) rice is more nutrition	
Q5 Price of rice is generally too high	
Q6 I prefer organic rice	
Q7 Brown rice is healthier than white rice	
Q8 I prefer brown rice compared to white rice	
Q9 Brown rice is more expensive than white rice	
Q10 I prefer to pay more for brown rice	

model, with a likelihood ratio test used to assess significance. All statistical analysis significance levels were set at $p < 0.05$.

Results and discussion

The baseline demographic indicates that marginally more of the farmers were male (52%) with a median age of 45.5 years and had 17.0 years of farming experience. Before turning to rice farming, farmers had job experience in the armed forces (9%), clerical (41%), construction (8%), healthcare (3%), services (21%), and academia (7%). A plurality of farmers lived in households where family members' job nature was related to non-farming activities, such as armed forces (11%), clerical (20%), service (46%), and teaching (10%). Surprisingly, 65% of the farmers had achieved higher education from tertiary schools, colleges, or universities. All farmers owned their paddy land with a median size of 1.0 (0.3–6.0) hectares that could produce a median weight of 2.8 (0.5–16.0) tons of rice for commercialization. Besides rice, the farmers cultivated other crops such as bananas (7%), cassava (27%), coffee (19%), lemon (3%), sugarcane (2%), vegetables (5%), and mixed (3%).

Differences between Millennials and GenX/Boomer II farmers

The Millennial farmers ($n = 45$) were not significantly different from those of Gen X/Boomer II ($n = 55$) in terms of educational level, size of paddy land, size of harvested rice, and size of rice sold. However, these Millennials were mostly females ($X^2 = 11.4$, $p = 0.001$) with less than 15 years of farming experience ($X^2 = 30.7$, $p = 0.001$) (Fig. 2). Concerning farming practices, there were no significant differences in terms of soil water monitoring techniques and machine farming practices between Millennials and Gen X/Boomer II farmers. When compared with Gen X/Boomer II, however, the Millennial farmers were more likely to adopt crop rotation to sustain farming ($X^2 = 6.4$, $p = 0.04$) and practice irrigation every few days ($X^2 = 20.1$, $p = 0.001$). All Millennial farmers were likely to practice the non-pesticide method ($X^2 = 9.1$, $p = 0.002$), and apply chemical and organic fertilizers ($X^2 = 8.1$, $p = 0.02$) during rice farming (Fig. 3).

Farmer characteristics were closely related to the farmer's capacity to undertake farm management and promote productivity. In this study, although not significantly associated, we found nearly two-thirds of farmers achieved a high level of formal education. This is inconsistent with the literature [24, 46, 49], where it has been found that poor education and low literacy reinforce lower levels of confidence, which constrain their capacity to abandon agricultural work. Despite the traditional view that farming is predominantly undertaken by those with lower levels of education, one possible aspect to consider is the impact of land fragmentation and ownership of resources on productivity and technical efficiency in rice production, that influence the decision-making process of educated people to consider rice farming as a viable career pathway [38]. In Laos, there has been a push for modernization and the adoption of new agricultural technologies [3], promoting a more modern and efficient approach to rice farming, so that educated individuals may see opportunities for growth and development in the rice farming sector. Furthermore, the government's support for low-chemical rice production in Laos could be another factor influencing educated individuals to enter the rice farming sector [9]. With growing awareness of environmental issues and the importance of sustainable practices, educated individuals may be drawn to rice farming as a way to contribute to

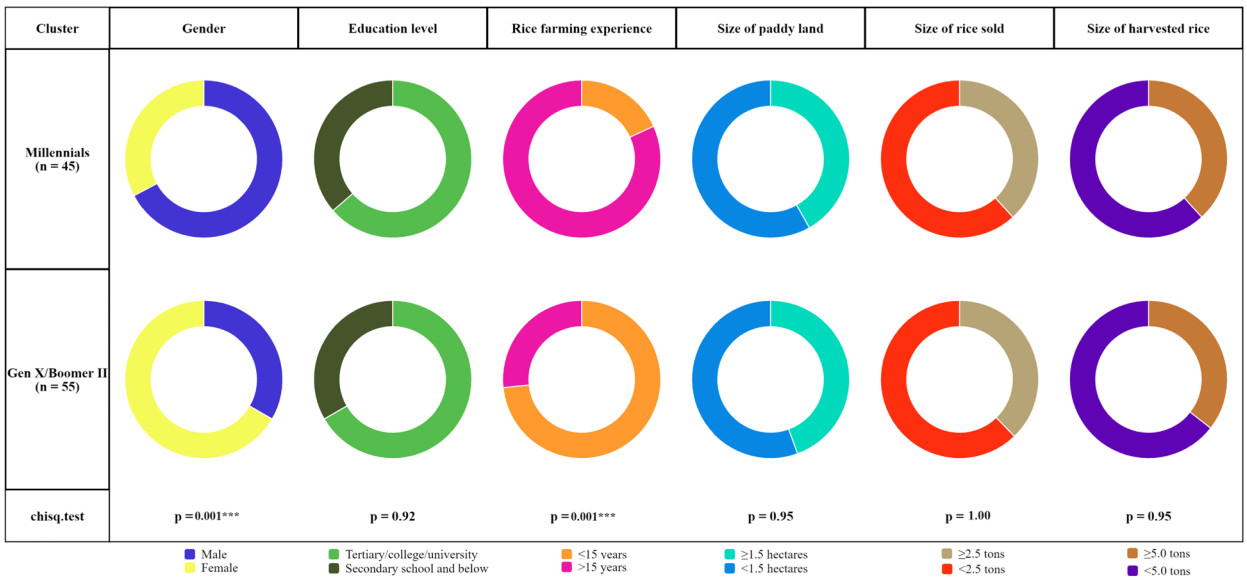
Table 2 Characteristic and farming details of rice farmers studied (n = 100)

Parameters	Characteristic	Frequency (n)
Demographics & household		
Gender	Male	52
	Female	48
Age (year)	Millennials (28–43)	45
	Gen X (44–59)	47
	Boomer II (60–69)	8
Educational level	No schooling	9
	Primary school	20
	Secondary school	6
	Tertiary/college/university	65
Number of family members	3–5 people	51
	6–11 people	49
Job nature of household members	Armed force	11
	Clerical worker	20
	Health professional	3
	Service worker	46
	Teaching professional	10
	Farmer	10
Farm and crop property		
Rice farming experience	≤ 15 years	43
	> 15 years	57
Job before rice farming	Armed force	9
	Clerical worker	41
	Construction worker	8
	Rice farmer	11
	Health professional	3
	Service worker	21
	Student	1
	Teaching professional	6
Rice farming frequency	All time	78
	Sometimes	22
Farming hour	3–4 h	53
	5–8 h	47
Size of paddy land	< 1.5 hectares	57
	1.5–3.0 hectares	37
	> 3.0 hectares	6
Size of harvested rice	< 5.0 tons	63
	5.0–10.0 tons	34
	> 10.0 tons	3
Size of rice sold	< 2.5 tons	62
	2.5–5.0 tons	22
	> 5.0 tons	16
Ownership of paddy land	Own	100
	Rent	0
Ownership of other croplands	Banana	7
	Cassava	27
	Coffee	19
	Lemon	3
	Melon	2
	Sugarcane	2
	Vegetables	5
	Mixed crop	3
	None	32

eco-friendly agricultural methods and meet market demands for organic and low-chemical produce.

Our study seemed to validate the role of education in promoting more sustainable practices. We observed literate Millennial farmers increasingly favoring eco-friendly, sustainable practices such as crop rotation, non-pesticide practices, and use of organic fertilizers in rice farming compared to older farmers (Gen X/Boomer II). In our study, sustainable practices are defined as agricultural methods that aim to maintain or enhance environmental quality and resource conservation, while eco-friendly practices refer to techniques that minimize negative impacts on the environment [11]. Studies have shown that younger farmers, like Millennials, are more inclined toward adopting sustainable farming practices to reduce chemical use [11]. The shift toward non-pesticide practices among Millennials can be attributed to concerns about health and environmental impacts associated with pesticide use, thus being more inclined to explore alternative pest management strategies [29]. In addition to health and environmental considerations, the preference for organic fertilizers among Millennials in rice farming can be linked to changing consumer preferences and market demands. Research has shown that the Chinese market for organic rice from Laos is driving a reduction in pesticide and herbicide use, encouraging the adoption of high-yielding rice varieties and organic farming practices [8]. This market-driven shift toward organic production methods could incentivize Millennials to embrace organic fertilizers as a means to meet consumer expectations and tap into lucrative markets.

Despite the positive impact of education, aging can deteriorate farmers' operating capabilities [40]. Our study demonstrates that rice farming in Champassak Province is predominantly undertaken by older farmers,



***Significant at $p < 0.001$.

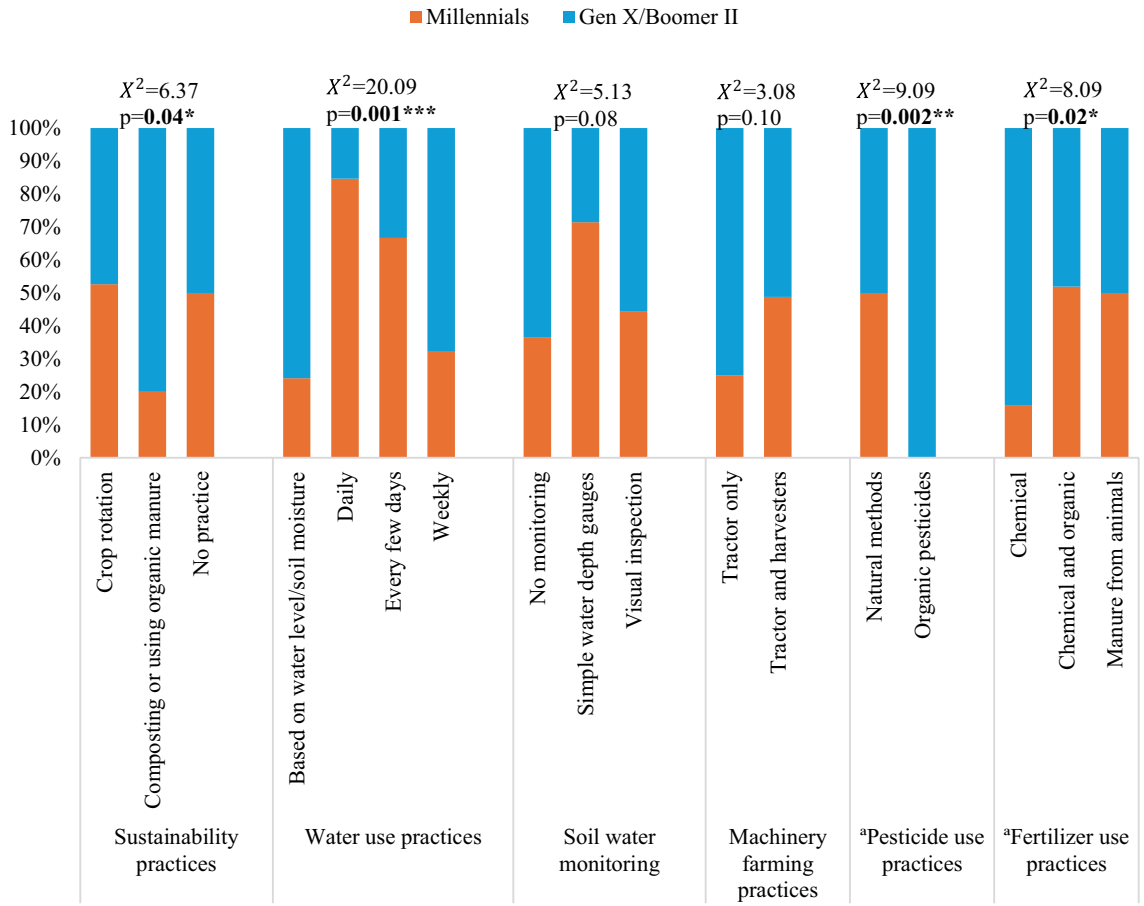
Fig. 2 Variable differences between Millennials and Gen X/Boomer II farmers

specifically from the generations of Millennials (28–43 years), Gen X (44–59 years), and Boomer II (60–69 years). This observation highlights a noticeable absence of younger farmers, particularly from Gen Z (12–27 years) in our sample. While Gen Z participants were not included in our study, this generational gap is supported by broader demographic trends and literature indicating declining youth participation in agriculture [12, 15, 16]. According to HelpAge International (2014), 22.1% of farmers in Laos are over the age of 55 years [48]. This observation aligns with broader demographic trends observed in rural populations, where aging is a significant factor affecting agricultural labor dynamics. To further substantiate this finding, Bhandari & Mishra [12] provide evidence of the aging farming of similar contexts in Asia [12].

These studies highlight the challenges posed by an aging workforce in agriculture and underscore the need for strategies to engage younger generations in farming. No doubt older farmers, who have been practicing rice farming for a longer period, may be more inclined to continue with the traditional methods due to familiarity and resistance to change [44] or lack of non-farm employment opportunities [1]; and they may experience a decline in productivity and efficiency as they age. It has been observed that with increasing age, farmers may become less efficient in arable crop production including rice indicating that older farmers could become less efficient over time [33]. This conflicting evidence underscores the complexity of how age interacts with farming practices and outcomes.

The impact of aging in the agricultural sector underscores the importance of youth participation in enhancing productivity in rice farming. While our sample includes a relatively balanced number of participants from Gen Y (n = 45) and Gen X/Boomer II (n = 47), it does not fully capture the broader trend of youth moving away from agriculture. This trend is supported by studies and reports highlighting factors such as low incomes resulting in insufficient financial gain, high risk, perceived low status, market fluctuations, and lack of credit [42]. For instance, Cole et al. [13] highlighted the significant role of migration and remittances in the rural livelihoods of Southeast Asia, including in Champassak [13]. The study reveals that many households in Champassak province increasingly rely on wage work, emphasizing youth migration to neighboring Thailand. Although the transition from subsistence to commercial production among smallholder farmers in Laos is a notable trend [2], rice farming in Laos remains the least commercialized within the Lower Mekong region [28], which constraints the incentives for farmers to intensify production beyond household needs. This broader context is crucial for understanding the challenges of engaging youth in farming and developing strategies to address these barriers.

The dynamics of gender participation in rice farming vary between generations. We observed more women



[a] Chi-square test with more than 20% of cells having an expected count of less than 5.

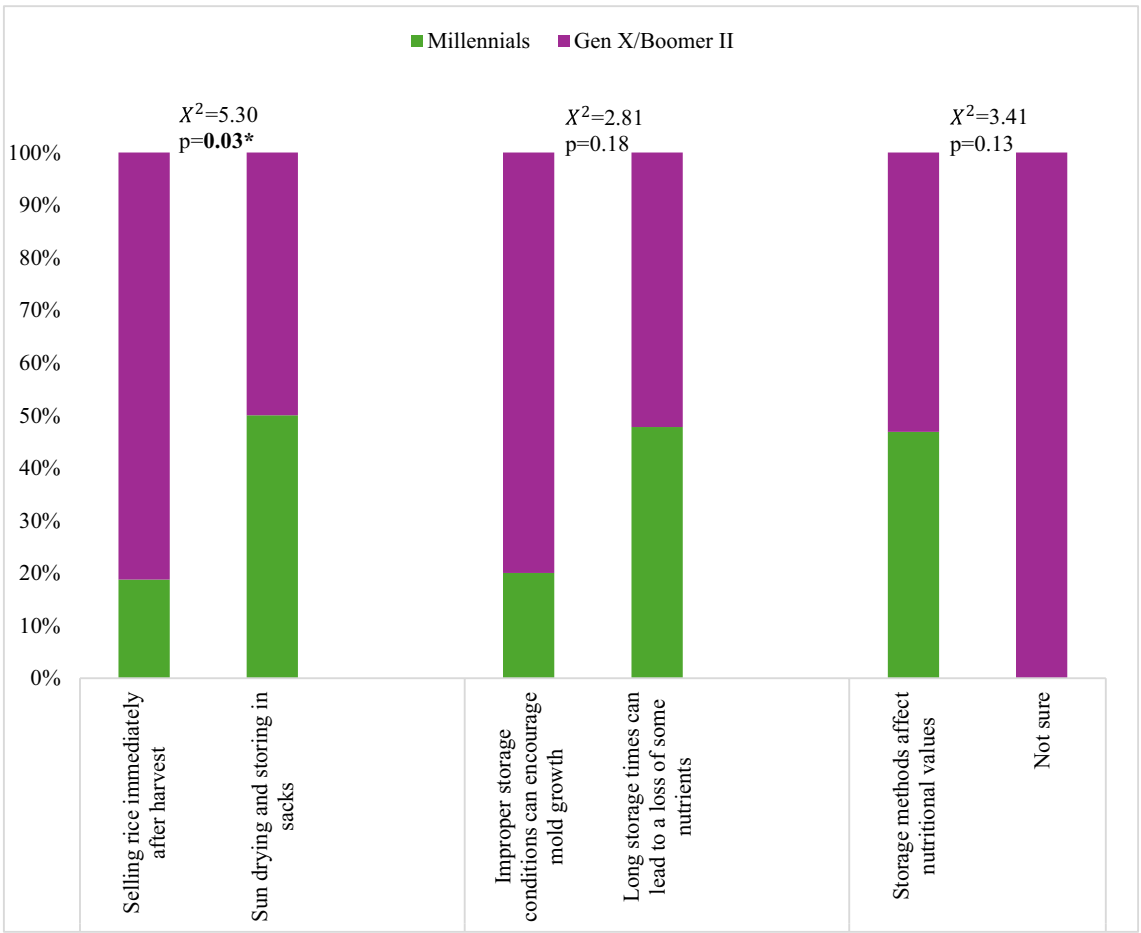
Significant at ***p < 0.001; **p < 0.01; *p < 0.05.

Fig. 3 Farming practices between Millennials and Gen X/Boomer II

engaged in Millennial households while more men in Gen X/Boomer II households, indicating a shift in gender roles within rice farming communities. The evolution of gender roles in rice farming is not unique to Laos but is a phenomenon observed in various agricultural contexts globally. This observation could also be attributed to a combination of factors that influence decision-making, labor allocation, and empowerment within farming communities. Studies such as those in Africa [30], Nigeria [5], Bangladesh [37], and Philippines [27] provide insights into the labor distribution and decision-making processes among men and women in rice-producing households, highlighting the nuanced roles each gender plays in agricultural activities. These findings suggest that women play a crucial part in agricultural activities, challenging traditional perceptions that may have marginalized their contributions. The empowerment of women in rice production has been recognized as a strategy to enhance overall productivity and sustainability in farming communities. [39] advocate for promoting women's participation in rice production, aligning with the goals of sustainable development. By empowering women and recognizing their contributions to farming activities, communities may achieve greater agricultural success and resilience in the face of changing environmental and economic conditions.

Post-harvest rice storage

We noticed that Millennial farmers significantly differed in their rice storage method compared to Gen X/Boomer II farmers. More than 90% of Millennial farmers preferred storing rice in sacks after sun drying



[a] Chi-square test with more than 20% of cells having an expected count of less than 5.

*Significance at $p < 0.05$.

Fig. 4 Post-harvest experience between Millennials and Gen X/Boomer II

($X^2 = 5.3$, $p = 0.03$) in contrast to older farmers who opted for direct selling (Fig. 4). These decisions could be influenced by a combination of practical and economic considerations. On the economic side, storing rice not only allows farmers to manage the supply of rice in the market but also enables farmers to take advantage of potential price increases that may occur post-harvest when demand surpasses supply. By controlling the release of rice into the market, farmers may have the opportunity to sell their produce at more favorable rates, especially during periods of high demand. Studies have delved into the motivations behind farmers' choices to store their harvest, revealing that factors such as estimating the frequency of sale until the next harvest season, examining reasons for saving crops, and analyzing the role related motivations play a role in farmers' decisions [7]. Immediate selling practices, on the other hand, may be a practical solution for older farmers. Although we did not investigate the theory behind immediate selling, possible explanations could be that the risk of pest damage in stored rice can lead to substantial losses for farmers, or limited storage facilities and equipment for rice production that encourage them to sell paddy rice to nearby rice community enterprises, cooperatives, or factories immediately following harvesting.

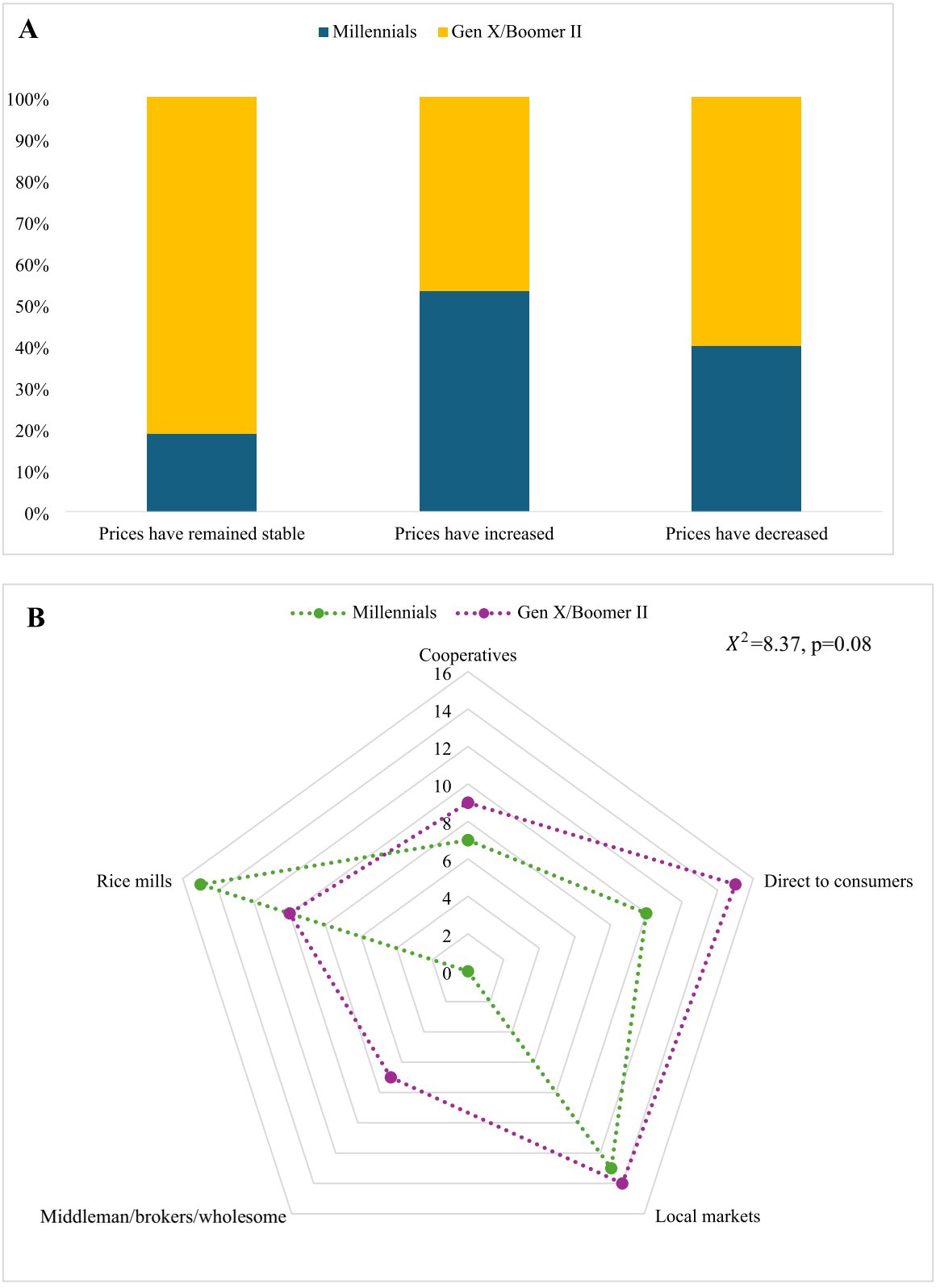
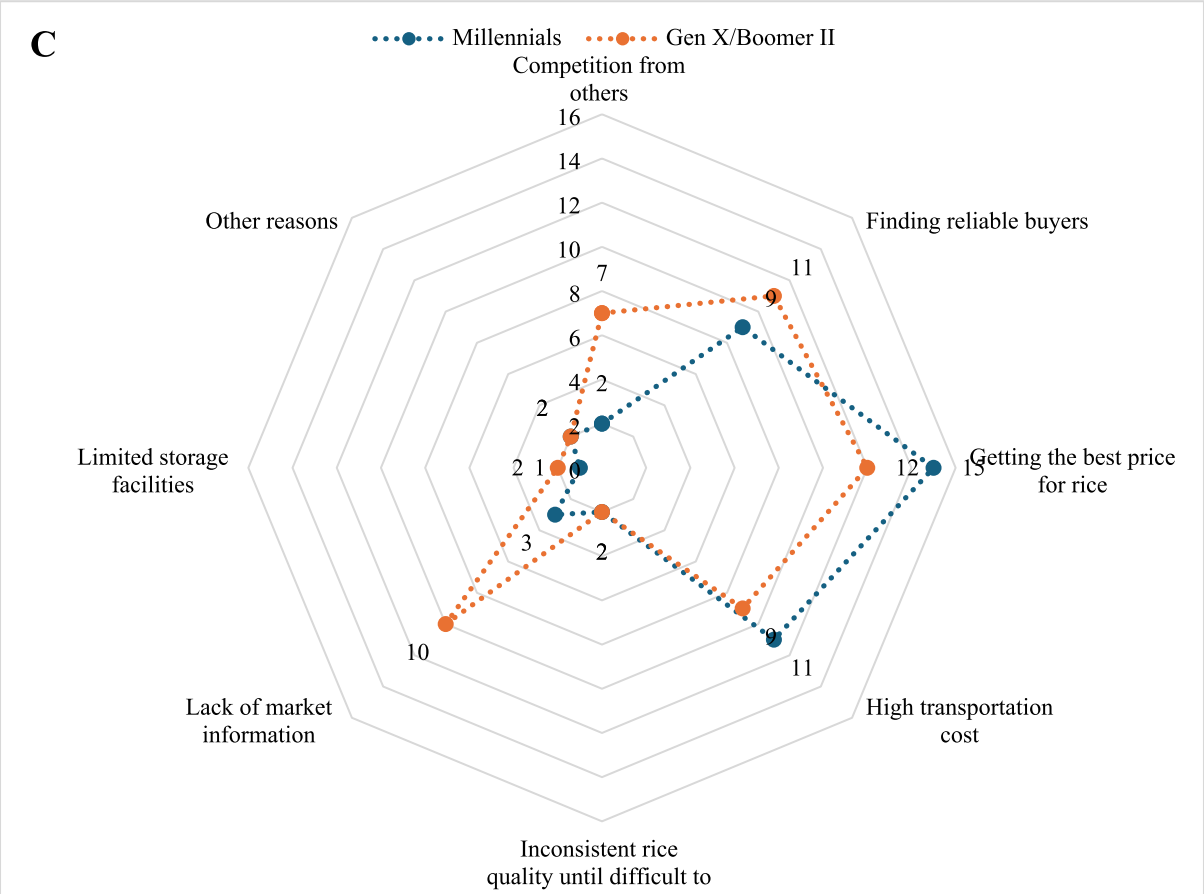


Fig. 5 Farmer's perception and challenges of rice price (**A**), rice selling (**B**), and rice marketing (**C**)



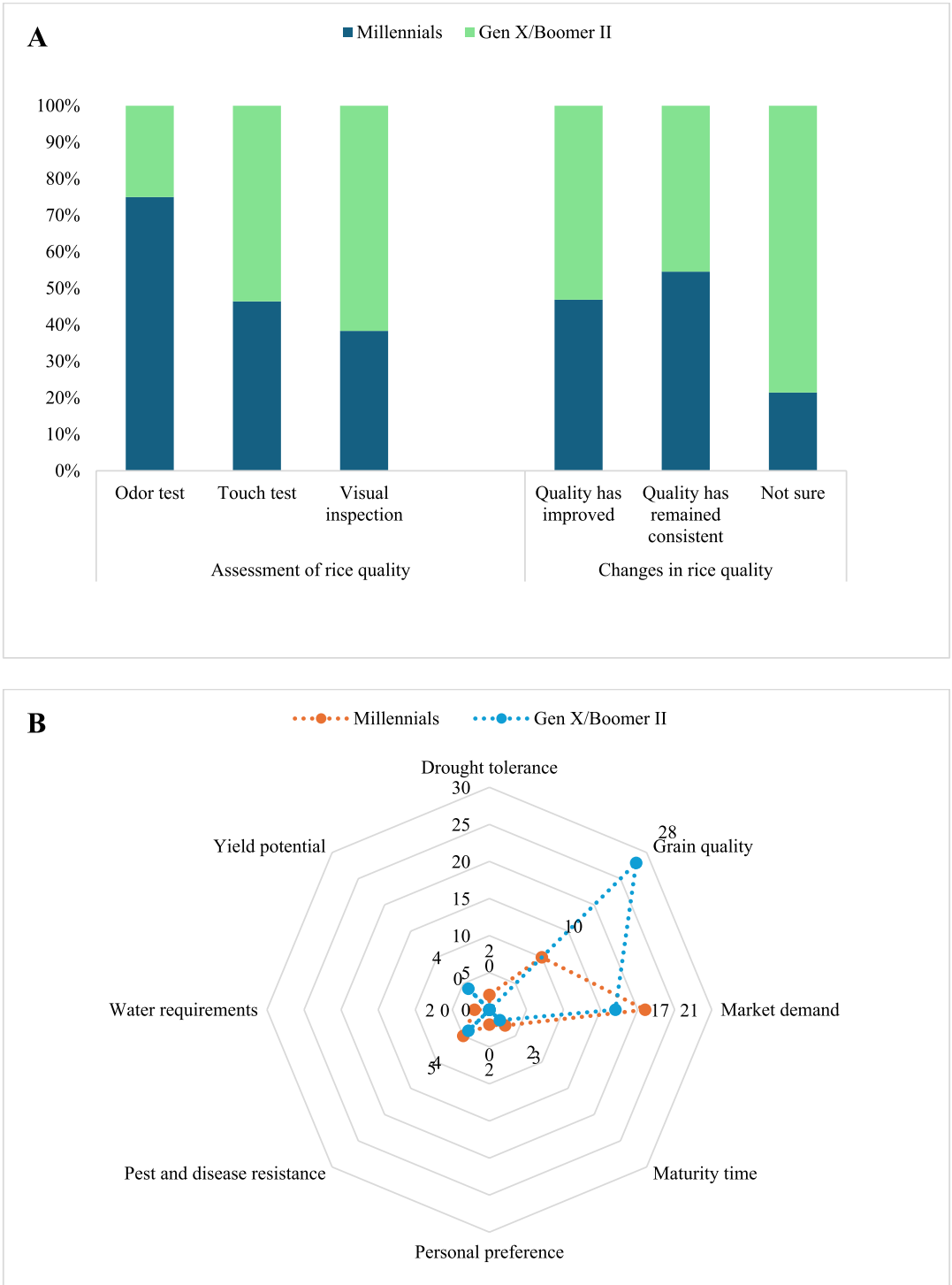
Chi-square test with significance at * $p< 0.05$.

Fig. 5 continued

Rice marketing and economics

There was a statistically significant difference in perceived changes in rice prices between Millennials and Gen X/Boomer II farmers. Compared with Gen X/Boomer II, more than 75% of the Millennial farmers noticed rice prices have increased in recent years ($X^2 = 6.3$, $p = 0.04$) (Fig. 5A). Among all the typical rice-selling channels, Millennial farmers prefer rice milling operators (33.3%) and local markets (28.9%) (Fig. 5B). None of them opted for middleman or brokers or wholesale. By contrast, Gen X/Boomer II farmers prefer the alternative of selling rice directly to consumers (27.3%) and local markets (25.5%). Farmers perceived a variety of barriers when marketing their rice. 'Getting the best price for rice' was the biggest challenge for both Millennials (33.3%) and Gen X/Boomer II (21.8%) farmers, followed by 'High transportation cost' (Millennials = 24.4%, Gen X/Boomer II = 16.4%), 'Finding reliable buyers' (Millennials = 20.0%, Gen X/Boomer II = 20.0%), and 'Lack of market information' (Millennials = 6.7%, Gen X/Boomer II = 18.2%) (Fig. 5C).

Price stability and fluctuations in rice prices can significantly impact farmers, as demonstrated in a study on the impact of oil price shocks on rice prices in the ASEAN region [17]. Price shocks, whether due to external factors like oil prices or internal market dynamics, can disrupt the rice market and create uncertainties for farmers in Champassak, making it challenging for them to predict and secure stable prices for their rice produce. Besides, the presence of intermediaries in the rice supply chain can exacerbate the pricing challenges faced by rice farmers in Champassak. A study by Kharel et al. [23] on rice marketing systems in Nepal highlighted how the involvement of various market actors such as collectors, millers, and wholesalers can impact price negotiations and consumer prices of rice. This scenario is relevant to Champassak, where similar intermediary practices may exist, leading to discrepancies between farm gate prices



[a] Chi-square test with more than 20% of cells having an expected count of less than 5.Significance at * $p < 0.05$.

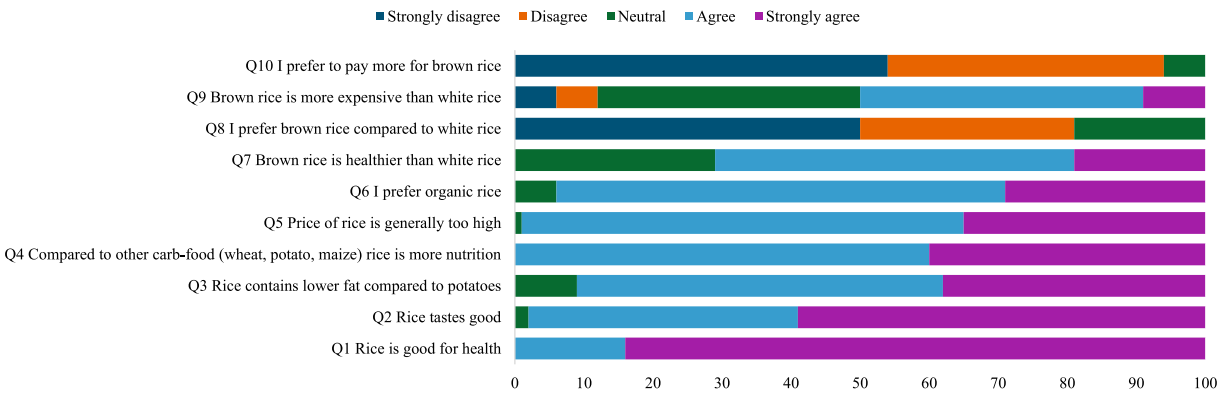
Fig. 6 Perception of rice quality (**A**) and factors influencing the choice of rice seed (**B**)

and consumer prices. Such market structures can make it difficult for rice farmers in Champassak to receive fair prices for their produce, as intermediaries often capture margins along the supply chain.

Rice quality and nutrition

The Millennial farmers did not differ significantly from the Gen X/Boomer II farmers with regards to the method for assessing rice quality assessment (Fig. 6A). The majority of Millennial (51.1%) and Gen X/Boomer II (67.3%) farmers adopted the visual inspection method to assess the quality of their rice following harvest, while a minority used the touch test (Millennial = 28.9%, Gen X/Boomer II = 27.3%) or odor test (Millennial = 20%, Gen X/Boomer II = 5.5%) methods. Moreover, both Millennials (66.7%) and Gen X/Boomer II (61.8%) farmers acknowledged the improved quality of their rice in recent years. However, we observed that Millennials and Gen X/Boomer II farmers held significantly distinct perceptions when choosing rice varieties for planting ($X^2 = 18.4$, $p = 0.01$) (Fig. 6B). The majority of the Millennial farmers considered 'Market demand' (46.7%) the most important factor, while Gen X/Boomer II most often based their decision on 'Grain quality' (50.9%). Interestingly, none of the Gen X/Boomer II farmers considered factors such as 'Drought tolerance', 'Personal preference', and 'Water requirement'.

Our study indicates that Millennials tended to prefer market demand-driven traits, while older farmers leaned toward characteristics like grain quality. This preference divide can be attributed to various factors, including generational differences, market dynamics, and the evolving agricultural landscape in Champassak. Research by Efisue et al. [14] sheds light on farmers' perceptions of rice varieties and their implications for breeding research, emphasizing the importance of understanding farmers' preferences in developing new cultivars. This insight is crucial in comprehending why Millennial farmers, who are likely more attuned to market trends and consumer demands, would favor rice varieties aligned with market preferences. Furthermore, a study by Ririn Puspita et al. [41] on social media utilization among Millennial farmers in Yogyakarta pointed to the role of information technology in improving agricultural practices. This technological integration may also influence the preferences of Millennial farmers toward market-driven traits that are in line with consumer demands and market trends. On the other hand, older farmers' inclination toward drought-tolerant rice varieties may be linked to their experience dealing with climatic challenges over the years. Studies like the one by



	Q1 Rice is good for health	Q2 Rice tastes good	Q3 Rice contains lower fat compared to potatoes	Q4 Compared to other carb-food (wheat, potato, maize) rice is more nutrition	Q5 Price of rice is generally too high	Q6 I prefer organic rice	Q7 Brown rice is healthier than white rice	Q8 I prefer brown rice compared to white rice	Q9 Brown rice is more expensive than white rice	Q10 I prefer to pay more for brown rice
Strongly disagree	0	0	0	0	0	0	0	50	6	54
Disagree	0	0	0	0	0	0	0	31	6	40
Neutral	0	2	9	0	1	6	29	19	38	6
Agree	16	39	53	60	64	65	52	0	41	0
Strongly agree	84	59	38	40	35	29	19	0	9	0
Mean	4.84	4.57	4.29	4.4	4.34	4.23	3.9	1.69	3.41	1.52
σ	0.37	0.54	0.62	0.49	0.5	0.55	0.69	0.78	0.96	0.61
Decision^	5	5	5	5	5	5	4	1	4	1

^Overall agreement interpretation where 5=strongly agree, 4=agree, 1=strongly disagree.

Fig. 7 Perception of rice nutrition

[20] on farmers' perceptions of drought and mitigation strategies in Uganda highlight how farmers' experiences with production constraints influence their preference for particular varieties, with drought tolerance being a key trait sought after by farmers facing such challenges. Research by Atera et al. [6] on rice production and marketing in Kenya underscores the significance of rice farming for contributing to household food security and income generation, especially during periods of poor weather conditions. This economic aspect could explain why older farmers, who may prioritize stability and resilience in their farming practices, value traits like drought tolerance over market demand-driven characteristics.

To elucidate farmers' perceptions of rice nutrition, participants were asked for their level of agreement with statements based on a 5-point Likert scale (Fig. 7). Farmers generally had a high level of agreement toward 'Rice is good for health' (mean = 4.84), 'Rice tastes good' (mean = 4.57), 'Rice contains lower fat compared to potatoes' (mean = 4.29), 'Compared to other carb-food (wheat, potato, maize) rice is more nutrition' (mean = 4.40), 'Price of rice is generally too high' (mean = 4.34), 'I prefer organic rice' (mean = 4.23), 'Brown rice is healthier than white rice' (mean = 3.90), and 'Brown rice is more expensive than white rice' (mean = 3.41). On the other hand, farmers had strong disagreements toward the statements 'I prefer brown rice compared to white rice' (mean = 1.69) and 'I prefer to pay more for brown rice' (mean = 1.52). While they agreed that brown rice is the healthier option, preference for white rice remains prevalent in regions like Champassak. This may be influenced by cultural norms, taste preferences, and culinary traditions that

Table 3 Univariable and multivariable logistic regression analyses of sustainable practices for rice yield

	Univariable analysis		Multivariable analysis	
	OR (95% CI)	p	aOR (95% CI)	*p*
Age generation				
Millennials	0.89 (0.39–2.02)	0.78	–	–
Gen X/Boomer II	Ref	–	–	–
Household size				
3–5 people	0.02 (0.00–0.08)	0.001*	0.01 (0.00–0.06)	0.001*
6–11 people	Ref	–	Ref	–
Water use practices				
Based on the water soil moisture	0.23 (0.065–0.80)	0.021*	0.11 (0.02–0.63)	0.01*
Daily	2.28 (0.62–8.46)	0.22	5.1 (0.48–53.25)	0.17
Every few days	1.21 (0.42–3.46)	0.72	1.87 (0.31–11.21)	0.49
Weekly	Ref	–	Ref	–
Pesticide use practices				
Organic pesticide	0.39 (0.08–1.96)	0.25	–	–
No organic pesticide	Ref	–	–	–
Soil water monitoring				
Simple water depth gauges	16.36 (3.14–85.09)	0.001*	–	–
Visual inspection	1.23 (0.48–3.14)	0.66	–	–
No monitoring	Ref	–	–	–
Machinery farming practices				
Tractor and harvester	5.0 (1.06–23.41)	0.04*	–	–
Tractor only	Ref	–	–	–
Fertilizer use practices				
Chemical/organic	0.58 (0.04–9.56)	0.70	–	–
Manure from animals	Ref	–	–	–
Sustainable practices				
Crop rotation/composting	0.32 (0.14–0.74)	0.01*	0.17 (0.04–0.77)	0.02*
No practice	Ref	–	Ref	–

Variables entered in step 1 were eliminated in step 2 (fertilizer use practices), step 3 (pesticide use practices), step 4 (machinery farming practices), step 5 (age generation), and step 6 (soil water monitoring), and retained household size, water use practices, and sustainable practices

aOR, adjusted odds ratio; *Significance at $p < 0.05$

have long favored white rice as the primary grain in local diets. This cultural preference for white rice is deeply ingrained in Champassak farmers, and hence, they may be less inclined to invest in brown rice that may not align with their current income strategies. It could also relate to household consumption expenditure, where a self-sufficient family is hesitant to pay for high-priced food.

Factors influencing rice yield

Univariate analysis revealed that the use of simple water depth gauges (OR = 16.36, 95% CI = 3.14–85.09), p = 0.001) and tractor and harvester (OR = 5.0, 95% CI = 1.06–23.41, p = 0.04) were significantly associated with increased rice yields (Table 3). By contrast, the variables of household size, water use based on water level/soil moisture, and crop rotation/composting were inversely associated with increased rice yields. After controlling for all variables (age generation, household size, water use, pesticide use, soil water monitoring, machinery farming, fertilizer use, and sustainable methods), the final multivariable analysis revealed that smaller household size (aOR = 0.01, 95% CI = 0.00–0.06, p = 0.001), irrigation based on soil moisture (aOR = 0.11, 95% CI = 0.02–0.63, p = 0.01), and crop rotation/composting (aOR = 0.17, 95% CI = 0.04–0.77, p = 0.02) were inversely associated with increased rice yields.

Consistent with Saokhamkeo et al. [45], larger families especially in rural areas may face food insecurity at the household level because they prefer to store sufficient rice for their consumption before the next rice harvest period. The larger the household, the more rice is required for consumption. While larger family sizes can provide labor resources for rice farming, larger family sizes may face challenges in coordinating and optimizing labor allocation, potentially straining available resources and reducing the overall efficiency of farming contributing to decreased rice yield [18, 34]. Another study on rice cultivation in Ghana has shown that higher family labor prices can negatively impact farmers' profits, indicating that larger families with more labor inputs may face financial challenges in rice cultivation [57]. These economic factors, combined with the labor dynamics within larger families, can contribute to a scenario where family size negatively affects rice yield in Champassak. Considering soil moisture-based irrigation, studies have shown that soil moisture levels act as a proxy for local water availability, directly affecting crop yield and production [50]. In Champassak regions with erratic rainfall patterns or climate influences, such irrigation practices may increase soil moisture tension and impact root and shoot responses in rice plants, thus affecting nutrient availability and uptake by the plants [31]. The inverse association of increased rice yield with crop rotation and composting was an unexpected finding. This risk factor has not been reported elsewhere and requires further investigation to better understand its potential implications within Champassak's rice farming.

Despite our research providing detailed insight into perceptions and challenges related to rice farming in Champassak, study limitations must be acknowledged. Our study involved small sample sizes and only focused on rice farmers in Champassak province, and hence, the results cannot be generalized to other crops growing or to the whole rice farming community in Champassak. In addition, this study was cross-sectional; our data were acquired during a limited time frame and might not be representative of the whole population. However, farmer characteristics are comparable with rice farmers of the Vientiane capital [45] and Savannakhet province [8]. Regarding multivariable analysis, more variables could be incorporated into the regression model to improve the precision of predictions. This, however, is unlikely to help because it would increase model complexity and thus affect the inference and accuracy of the estimated parameters.

Conclusion and future perspectives

This study was the first of its kind to provide evidence of the perceptions and challenges of rice farmers in Champassak. The combination of insights on demographics, farming practices, post-harvest management, rice nutrition, and marketing challenges can shed light on the farmers' current situation and inform a framework for addressing food security and community empowerment, contributing to the Laotian government's mission toward transitioning rice farming from subsistence to commercialization.

Our research highlighted a generational gap between Millennials and older farmers, with significant differences in gender, rice farming experience, and farming practices, as well as varying approaches to post-harvest management and consideration of rice varieties. One of the key challenges identified was the pursuit of obtaining the best price for rice in the market, indicating a need for tailored policy intervention to bridge these generational gaps and address the challenges faced by rice farmers in Champassak.

Several implications can be drawn for policy recommendations.

- Implementation of capacity-building program

Considering the significant differences between Millennials and older farmers in terms of farming practices and post-harvest management, it is essential to implement targeted capacity-building programs. These

programs should focus on providing training and support tailored to the specific needs of different age groups to enhance their skills and knowledge of modern agriculture practices. By bridging the generational gap through capacity-building initiatives, the adoption of improved farming techniques can be promoted among all farmers leading to increased productivity and competitiveness in the market.

- Strengthening market linkage and information access

Addressing the challenge of obtaining the best price for rice in the market, requires policy interventions that strengthen market linkages and improve access to market information for farmers. Implementing policies that enhance market transparency, facilitating direct farmer-market connections, and providing support for value-added processing can help farmers negotiate better prices for their produce. Moreover, promoting collective marketing initiatives and cooperatives among farmers can empower them to collectively bargain for fair prices and access larger markets.

- Promoting gender equality and equal participation

To address the gender disparities, gender-sensitive policies and programs need to be developed and implemented. These policies should aim to promote gender equality in access to resources, decision-making processes, and agricultural extension services. By ensuring equal participation and representation of women in agricultural activities and decision-making, the productivity and sustainability of rice farming in Champassak can be enhanced, contributing to overall food security and community empowerment.

- Encouraging and facilitating youth farming

To empower youth involvement, policy recommendations should include initiatives to provide financial support and access to credit for young farmers in Champassak. This could involve setting up special loan schemes with favorable terms for youth interested in agriculture, as well as facilitating access to inputs, equipment, and technologies through subsidies or grants to encourage their long-term commitment to agriculture. It is also essential to align policy interventions with broader national strategies for agricultural development and food security in Laos.

- Integrating national agricultural development plan

Integrating the findings of the study into the national agricultural development plans and policies can help prioritize investments, resources, and support mechanisms for rice farmers in Champassak. By mainstreaming the specific needs and challenges of rice farmers in Champassak into national policies, the government can ensure targeted and effective interventions that contribute to the overall goal of transitioning rice farming from subsistence to sustainable commercialization.

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Authors' contribution
PYW—research design, conception, data curation, formal analysis, visualization and result interpretation, first draft writing, editing, and validation. PS—data collection and data curation. KVP—questionnaire design. All authors reviewed and approved the submission.

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Data availability
The corresponding author can provide the data described in this study upon request.

Declarations

Competing interests
All authors declare no conflict of interest for this study.

Author details
[1]Department of Food Science and Nutrition, The Hong Kong Polytechnic University, Hong Kong Special Administrative Region, China. [2]Research Institute for Future Food (RiFood), The Hong Kong Polytechnic University, Hong Kong Special Administrative Region, China. [3]Faculty of Agriculture and Forestry, Champassak University, Champassak, Laos. [4]Food Technology, Vietnam National University Ho Chi Minh City University of Technology, Ho Chi Minh City, Vietnam.

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