Research Article

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Adaptation of rice farmers to aging in Thailand

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Abstract: As one of the fastest-aging countries globally, Thailand faces unique challenges in its agricultural landscape due to the accelerated aging of its farming population. As rice is the most important crop, it is essential to understand the perceptions of farmers regarding the effects of aging on rice farming and how they adapt to aging. This research examined the adjustments that rice farmers had made in their practices over the past 5 years to cope with this demographic shift. The study utilized survey data collected from 300 rice farmers across two prominent rice-producing provinces in Thailand. The findings revealed that 32% of the surveyed rice farmers had adapted to the challenges posed by aging. The top two adaptive strategies allowed descendants to be more involved in rice farming activities and utilization of labor-saving machinery. To analyze the factors influencing the decision to adapt to aging, a binary probit model was employed. The results indicated that several factors played a positive and significant role in the rice farmers' decisions. These included the farmer's age, the size of agricultural land, access to irrigation, land ownership, the farmer's perception of the impact of aging on rice farming, willingness to learn to use and embrace innovative technology for planting and harvesting, and a reduced number of farming activities performed through custom hiring services. Among these factors, irrigation, land ownership, and the farmer's perception of the aging impact were found to have a strong influence on the farmer's adaptation.

Keywords: adaptation, aging, rice farmers

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1 Introduction

Population aging is a global phenomenon. The projection is that the number of people aged 65 years or older worldwide is expected to more than double, reaching 1.6 billion in 2050 [1]. Thailand is among the fastest-aging countries in the world. Thailand's expected transition to a super-aged society within the next decade necessitates policies to cope with population aging [2]. However, the aging trend in Thailand is not evenly distributed and is notably pronounced in the agricultural sector. The data from Thailand's agricultural census showed that the proportion of agricultural workers over the age of 60 increased from 13% in 2003 to 19% in 2013, above the 2017 national average of 14%. On the other hand, the proportion of young farming laborers (15–40 years) decreased from 48% in 2003 to 32% in 2013. According to the Thai Farmer Registration Database, the share of farm operators over the age of 65 increased from 17% in 2016 to 25% in 2022. The share of farm operators younger than 45 years old declined from 29% in 2016 to 18% in 2022. The issue of aging agricultural workers and farm operators and the preference of younger individuals to seek employment outside of agriculture contribute to labor shortages in the agricultural sector. In addition, the high workability of farmers was inversely related to increasing ages, underscoring the physical challenges and potential decline in work capacity that can come with aging [3]. This highlights a significant challenge in achieving high productivity posed by aging in the agricultural sector.

The age-related impacts on agricultural productivity in Thailand were revealed by previous studies. The old-aged labor force (60 years and over) increased technical inefficiency, but the combination of the old-aged labor force with physical capital decreased inefficiency [4]. However, aging workers in the Thai agricultural sector cannot be easily replaced by machinery and young workers [5]. Hence, promoting farmer's adaptation in response to the challenges of aging is necessary. The limited number of studies on farmers' adaptation in response to the challenges of aging, particularly in Thailand, underscores the need for more research in this important area.

The existing literature studied intergenerational farm succession, retirement decisions of farmers, and various

land transfer options for farmers without successors [6–13]. Regarding factors affecting intergenerational farm succession, the age of the farm operator was found to be positively significant in explaining farm succession [12]. The gender of the farm operator was found to have both positive and negative effects. Most studies found a positive effect that the likelihood of having a farm successor is higher for a male operator [6,12,13]. On the other hand, a negative effect of male operators on the likelihood of having a farm operator was also found in the study of Glauben et al. [8]. The number of children, particularly those aged 13–18 years had a positive effect on the likelihood of succession [9,11], whereas Kimhi and Nachlieli [14] did not find an impact from the number of children on succession.

Farm characteristics, such as farm size, were positively associated with the likelihood of having farm succession due to better prospects of providing sufficient income and supporting rural livelihood [12] or due to fewer financial constraints [8]. In addition, the potential farm successors' involvement in farming activities was found to positively affect farm succession. Farmers with access to an irrigation system had a lower probability of continuing farming with changes compared to those without access to an irrigation system [10,13]. Farmers renting the land were more likely to stop farming and give the land to someone outside the family [10].

Only Januswan and Zander [10] specifically studied the case of Thailand in the context of the intended strategies of farmers to cope with aging. They found that the majority of farming respondents, constituting 61%, expressed the intention to stop farming. They planned to transfer the land to their children or someone outside their family. The remaining 39% of the respondents expressed the intention to continue farming. Most farmers who intended to continue farming planned to make changes (including changing crops, hiring additional labor, relying on younger family members, applying labor-saving technology, and/or reducing land size), while a small percentage expressed the intention to continue farming without making any changes. They concluded that having a successor, the types of products, subsidies, and old-age income security were significant factors that influenced farmers' decisions about their future in agriculture to cope with aging. However, the result of this study was not robust as the chosen study area in Prachin-Buri province does not represent a prominent agricultural production province in Thailand as only 37% of land use was for farming. Moreover, they focus on old-aged farmers' intentions to cope with aging in the next 5 years rather than the actual changes in their farming practices. In particular, the stated intentions do not fully align with actual behavior. The factors influencing farmers' intentions potentially overstate actual changes. In addition, developing proactive policies to encourage young and middle-aged farmers to adapt to the challenges of aging well before they reach old age is essential. Therefore, this article aimed to explore farmers' perceptions of the impact of aging, the adaptive strategies employed by farmers of all ages in response to aging challenges, and factors influencing adaptation.

The study specifically focuses on the perception and adaptation of rice farmers due to Thailand's prominence in rice farming and its crucial role in the livelihoods of agricultural households. In 2021, 4.7 out of 7.3 million farmer households in Thailand accounted for 65% of being involved in rice cultivation. Rice cultivation is challenged by declining rice yields, with the average yield decreasing from 2.64 tons per ha in 2020 to 2.60 tons per ha in 2021. Moreover, rice cultivation was much less efficient for older farmers [15]. Preparing rice farmers to adapt to aging is not only crucial for addressing demographic challenges but also holds the potential to enhance efficiency in rice production.

This study contributes to the existing literature on adaptation to aging, focusing on changes in rice farming practices employed by rice farmers of all age groups. This study also investigates the effect of farmers' perception of aging impact, willingness to learn to use and integrate innovative technology into their farming practices, and resource constraints on farmer's adaptation to aging. Factors representing resource constraints include farmland suitability for agricultural machinery or for cultivating other crops, insufficient savings, and the use of custom hiring services, which describes the context of Thai rice farmers who are small-scale and lack labor or financial resources to purchase and operate the required machinery for sowing and/or harvesting. This analysis can provide valuable insights, enhancing the adaptive capacities of farmers in the face of aging challenges.

2 Materials and methods

2.1 Theoretical and empirical framework

Decision-making for farmers' adaptation to aging can be explained by the conceptual framework of utility with random expectations to capture unpredictability factors. An individual farmer (Farmer i) decides whether to adapt or not to adapt in response to aging challenges to satisfy the highest utility expectation. A farmer will adapt to aging if the expected utility gained from adaptation is greater than the expected utility obtained from non-adaptation.

Let $E(U_{1i})$ represent the expected utility from adaptation, and $E(U_{0i})$ represent the expected utility from non-adaptation. The difference in the expected utility between two choices (adapt and not adapt) is defined by U_i. Therefore, farmer's adaptation takes place if

$$U_i = E(U_{1i}) - E(U_{0i}) > 0 \text{ or } E(U_{1i}) > E(U_{0i}).$$

The utility of farmer i is stochastic, and the deterministic component of utility is a function of exogenous variables (X_i), including observable demographic characteristics, farming characteristics, perception and willingness, and resource constraints:

$$U_i^* = \beta X_i + e_i. \quad (1)$$

However, U_i is not observable but the adaptation in farming practice to prepare for aging (A_i) is observable as a binary variable.

A farmer will adapt to aging ($A_i = 1$) if $U_i^* > 0$ or $E(U_{1i}) > E(U_{0i})$.

A farmer will not adapt to aging $A_i = 0$ if $U_i^* < 0$ or $E(U_{1i}) < E(U_{0i})$.

Equation (1) can be empirically estimated as equation (2) using a probit model.

$$A_i = \beta X_i + e_i. \quad (2)$$

The probit model assumes a normal distribution of random variables. The probability of a farmer to adapt to aging is conditioned on X, as shown in equation (3):

$$\text{Prob}(A_i = 1|X) = (\exp^{X'\beta})/(1 + \exp^{X'\beta}) = \phi(X_i'\beta). \quad (3)$$

$A_i = 1$ when farmer i has adopted at least one adaptation practice to respond to aging challenges during the past 5 years; otherwise, $A_i = 0$. $X_i'\beta$ is a vector of independent variables influencing farmers' decisions to adapt. Independent variables drawn from previous empirical studies that investigated factors affecting intergenerational farm succession were (i) demographic characteristic variables – age, gender, and number of household members; (ii) farming characteristic variables – farm size, access to irrigation system, and land tenure. Independent variables added from previous studies, including (iii) perception and willingness variables – farmer's perception of aging impact, and farmer's willingness to learn and embrace innovative technology; and (iv) resource constraints variables – farmland suitability for agricultural machinery or for cultivating other crops, insufficient level of savings, and the use of a custom hiring service.

Age, male gender, household size, farm size, access to an irrigation system, and land tenure were expected to have positive influences on rice farmers' adaptation. The way farmers perceived the effects of aging on their rice farming influenced the decision to implement changes in farming practices. A farmer's willingness to learn how to use and embrace innovative technology reflected their openness to new technology, which influenced their decision to adopt, particularly whether to adopt labor-saving machinery or technology. Farmland suitability, insufficient savings, and the use of custom hiring services were expected to have negative influences on a farmer's adaptation. Farmland suitability imposes a constraint that limits the adoption of labor-saving machinery and the cultivation of less labor-intensive crops. Insufficient savings limit a farmer's ability to access capital for labor-saving machinery, or alternative farming practices using less labor. Using a custom hiring service suggests a lack of labor, or a lack of financial resources and the necessary technical skills to purchase and operate labor-saving machinery.

2.2 Data collection

The primary data were collected from May to July 2023 by interviewing rice farmers using a questionnaire in Suphan Buri and Ubon-Ratchathani provinces, which are the largest rice production provinces in central and northeastern regions, respectively.[1] A total of 300 rice farmers were selected, which is above the threshold size of 200 for discrete choice model estimation [16]. An equal sample size of 150 samples was allocated for each province. In each province, the district with the largest number of rice farmers was selected. The sample frame included three age groups: less than 46 years, 46–60 years, and over 60 years. The distribution of farmers in each age group was based on the farmer registration data, with 20% less than 46 years, 50% aged 46–60 years, and 30% aged over 60 years. Proportionate sampling was employed to ensure that each age group was represented in the sample according to its actual proportion in the population. The specified sample size in this study included 30 farmers aged 25–45, 75 farmers aged 46–60 years, and 45 farmers aged more

1 The researchers followed ethical guidelines in the data collection. Before the interview, the researcher provided a clear explanation of the purpose and details of the questions to the farmers. Participation in the interview was voluntary. Farmers were given the choice to take part in the interview. Respondents were explicitly informed that they could leave the interview at any time without any consequences. Personal information, such as names and phone numbers, was not used for the analysis. This approach protected the privacy and confidentiality of the participants. All questions in the questionnaire were not associated with controversial issues that could cause mental or physical harm to the respondents.

than 60 years in each district. The farmers were randomly selected from the lists of farmers provided by the village chief in each district.

Informed consent: All participants involved in this study provided informed consent prior to their participation. They were informed about the purpose of the study, the questions to be asked during the interview, and their right to withdraw from the interview at any time without facing any consequences. Participation in the interview was entirely voluntary, and participants were assured that their personal information would remain confidential and would not be used for any purpose other than research. This study adhered to ethical guidelines, and participants were not exposed to any risks associated with controversial issues that could cause mental or physical harm.

2.3 Variable description and descriptive statistics

Table 1 describes the variables used in analyzing factors affecting rice farmers' adaptation. According to Table 1, 32% of the surveyed farmers implemented at least one adaptation practice in response to the challenges posed by aging. The average age of surveyed farmers was 54 years. The majority (62.7%) of surveyed rice farmers were men. The households had an average of four members and 3.86 ha of agricultural land. About 30% of the farmers had access to irrigation facilities. The proportion of owned and cultivated land was on average 77%. Half of the rice farming respondents perceived that aging has an impact on rice farming activities. Half of the respondents were willing to learn how to use and embrace innovative technology for planting and harvesting. About 29% of the farmers reported land unsuitability for cultivating crops other than rice or the adoption of machinery. About 79% of the farmers had insufficient savings. On average, the use of custom hiring services was reported for three rice farming activities, specifically for land preparation, growing, and harvesting activities.

3 Results and discussion

3.1 Perceived impact of aging on rice production

Farmers' perceptions of the impact of aging on rice production were categorized into four levels (No impact, Low, Moderate, and High). Almost half of the rice farmers perceived that aging had no impact on rice production. A total of 25, 24, and 13% of rice farmers perceived that aging had a

Table 1: Variable description and descriptive statistics

Variable name	Description	Mean	S.D.
Dependent variable			
Adapt	Dummy = 1 if the farmer had adopted at least one adaptation practice to respond to aging challenges during the past 5 years, 0 otherwise	0.320	0.467
Independent variables			
Demographic characteristic variables			
Age	Number of years from birth	53.83	12.078
Gender	Dummy = 1 if the respondent is male, 0 otherwise	0.627	0.484
Member	Total number of household members	4.210	1.697
Farming characteristic variables			
Size	Number of hectares of agricultural land	3.862	2.887
Irrigate	Dummy = 1 if access to irrigation facilities, 0 otherwise	0.303	0.460
Own	The proportion of owned land cultivated	0.766	0.39
Perception and willingness variables			
Aware	Dummy = 1 if the respondent perceived that aging has an impact on rice farming activities	0.513	0.501
Learn	Dummy = 1 if the respondent is willing to learn to use and embrace innovative technology	0.503	0.501
Resource constraint variables			
Unsuit	Dummy = 1 if the respondent reported farmland unsuitability for agricultural machinery or for cultivating other crops	0.290	0.455
Saving	Dummy = 1 if the respondent reported having insufficient savings for rice farming	0.79	0.407
Custom	Total number of rice farming activities (from land preparation to harvesting) that respondent used custom hiring	2.273	1.13

Table 2: Farmer' perceptions of the aging impact on rice production among different age groups (% of respondents)

Perceived impact	Under 46 years (*N* = 70)	46–60 years (*N* = 146)	More than 60 years (*N* = 84)	Whole samples (*N* = 300)
No impact	72.9%	50.7%	25.0%	48.6%
Low impact	8.6%	15.8%	10.7%	12.7%
Medium impact	15.7%	26.7%	26.2%	24.0%
High impact	2.8%	6.8%	38.1%	24.7%
Mean score[1]	0.86 (low)	0.90 (low)	1.77 (moderate)	1.05 (low)

F-statistics = 3.198, Prob. > *F* = 0.

[1]The interpretation criteria for the mean score on perceived impact: "No impact" within the score range 0–0.75, "Low impact" within the score range 0.751–1.50, "Moderate impact" within the score range 1.501–2.25, and "High impact" within the score range 2.251–3.

high impact, a medium impact, and a low impact on rice production, respectively. The average score of 1.05 on perceived impact is interpreted as low impact. This indicates an overall perception by the surveyed farmers that aging had a relatively minor influence on rice production. Significant differences in the mean score of perceived impact among different age groups of farmers were found. Specifically, the elderly group of farmers perceived the impact of aging at a moderate level, while farmers aged 46–60 years and those under 46 years old perceived the impact of aging at a low level (Table 2).

The physical decline experienced by old-aged farmers after reaching middle age contributed to their perception of the high impact of aging. In contrast, farmers aged 46–60 years perceived a low impact because they may not have experienced significant physical declines yet and individuals in this group, considered as "middle-aged" may still have relatively strong physical capabilities. Younger farmers, those under 46 years old, also perceived a low impact of aging. The possible reason is that this age group is likely to be in prime physical condition and, therefore, has not experienced significant declines in physical strength.

The mean score of adapted farmers' perceptions of aging impact was significantly higher than that of non-adapted farmers. The adapted farmers, who had already adjusted their farming practices in response to aging challenges, perceived the impact of aging at a moderate level, while non-adapted farmers perceived the impact of aging at a low level (Table 3). The higher perception among adapted farmers may indicate that these farmers were more aware of the aging challenges and had taken steps to adjust their farming practices accordingly. Non-adapted farmers may not perceive a high impact so they may not have implemented changes in their farming practices in response to aging.

3.2 Farmer's adaptive strategies

Rice farmers were asked whether they had implemented any adaptive strategies in the past 5 years to overcome aging challenges. Adaptive strategies included (1) allowing their descendants to be more involved in rice farming activities, (2) adopting more labor-saving machinery, (3) reducing the area where rice is planted, and (4) diversifying into perennial trees or additional crops that require less labor, as well as (if any) others. In response to aging challenges, 68% of the rice farmers did not adopt any adaptive strategy, while 32% did adopt at least one adaptive strategy (Table 4). The main adaptive strategy was allowing descendants to be more involved in rice farming activities (27%), particularly in growing and fertilizer application. The

Table 3: Adapted and non-adapted farmer' perceptions of aging impact on rice production (% of respondents)

Perceived impact	Adapted farmers (*N* = 96)	Non-adapted farmers (*N* = 204)	Whole samples (*N* = 300)
No impact	28.1%	58.3%	48.6%
Low impact	13.5%	12.3%	12.7%
Medium impact	34.4%	19.1%	24.0%
High impact	24.0%	10.3%	24.7%
Mean score[1]	1.54 (moderate)	0.81 (low)	1.05 (low)

t-statistics = 5.306, *p*-value = 0.

[1]The interpretation criteria for the mean score on perceived impact: "No impact" within the score range 0–0.75, "Low impact" within the score range 0.751–1.50, "Moderate impact" within the score range 1.501–2.25, and "High impact" within the score range 2.251–3.

Table 4: Rice farmers' adaptive strategies (% of respondents)

Adaptive strategies	<46 years (*N* = 70) (%)	46–60 years (*N* = 146) (%)	>60 years (*N* = 84) (%)	Whole samples (*N* = 300) (%)
Adapted at least one strategy to prepare for aging	**10.0**	**33.6**	**47.6**	**32.0**
Letting their descendants be more involved in rice farming activities	7.1	27.4	41.7	26.7
Adopting relatively more labor-saving machinery	2.9	9.6	9.5	8.0
Reducing rice planted area	1.4	4.1	6.0	4.0
Diversifying into perennial trees/less labor crops	4.3	2.8	2.4	3.0

Remark: One respondent can answer more than one adaptive strategy. The bolded values indicate the most frequently selected adaptive strategies by repondents within each subsample.

second most adopted strategy was the incorporation of labor-saving machinery, such as chemical spraying machines into rice farming practices (8%), aimed at alleviating the physical strain on farmers. A small percentage of farmers chose strategies such as reducing rice plantation areas (4%) and diversifying into perennial trees or additional crops that require less labor (3%).

Among the age groups, the highest proportion of farmers who adopted at least one adaptive strategy was found in the oldest age group (more than 60 years), while the lowest proportion was found in the young age group (under 46 years). Farmers in the oldest age group may be compelled to adopt as they directly experienced significant declines in physical strength. Farmers in the young age group may perceive themselves as less affected by aging challenges and might not prioritize proactive adaptation. Adaptive strategies were not different among age groups. Allowing descendants to be more involved in rice farming activities was a common adaptive strategy for farmers of all age groups.

Rice farmers were also asked to identify barriers to the adoption of each adaptive strategy. A major barrier to letting their descendants participate in rice farming activities was their desire to encourage other careers that are more comfortable. The identified barriers to adopting labor-saving machinery in rice farming included its suitability for the area where rice is planted. and cost effectiveness for small-scale farmers. The specific terrain, soil conditions, and land preparation requirements limit the feasibility of adopting machinery. The marginal size of land and the high investment and maintenance costs of machinery can make it economically unviable for small-scale farmers to adopt modern labor-saving machinery. The Suitability of land due to soil conditions or specific terrain or topography restricted the cultivation of other crops that require less labor. Moreover, lack of market access, lack of knowledge and technical expertise required for the successful cultivation of alternative crops, and unavailability of water were key barriers to growing other crops that most farmers addressed.

3.3 Determinants of rice farmer's adaptation to aging

Table 5 shows the estimated results of factors affecting rice farmers' adaptive decisions using the binary probit model. The model's overall fit has a high level of confidence in explaining the likelihood of farmers adapting to aging as the likelihood statistics is significant at the 99% level of confidence. Correlation coefficients between the

Table 5: Estimated results of factors affecting rice farmer's adaptive decisions

Variable	Coefficient	Robust S.E.	Marginal effect	Robust S.E.
Age (year)	0.0367***	0.00897	0.0124***	0.00296
Gender (1 = male)	0.206	0.177	0.0684	0.0575
Members (persons)	0.029	0.047	0.010	0.0159
Size (ha)	0.0101**	0.00498	0.00340**	0.00168
Irrigate (1 = access to irrigation facilities)	0.614**	0.266	0.218**	0.0970
Own (% owned land)	0.519*	0.299	0.175*	0.101
Unsuit (1 = unsuitability of land)	−0.124	0.208	−0.0411	0.0676
Aware (1 = low/moderate/high impact,0 = no impact)	0.503***	0.186	0.168***	0.0614
Learn (1 = willing to learn to use and embrace technology)	0.297*	0.177	0.0999*	0.0586
Savings (1 = insufficient savings)	0.294	0.222	0.093	0.067
Custom (number of farming activities performed through custom hiring services)	−0.232***	0.0882	−0.0784***	0.0292
Constant	−3.005***	0.630		
Log likelihood	−155.45			
Prob. > Chi^2	0			
Observations	300			

***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$.

independent variables fall within the range of −0.31 to 0.31, suggesting that the variables are not highly correlated. The mean-variance inflation factor value of 1.38 suggests that there is no significant problem with multicollinearity.

Factors that are statistically significant in explaining the decision to adapt included the farmer's age, the size of agricultural land, access to irrigation, land ownership, the farmer's perception of the impact of aging on rice farming, willingness to learn to use and embrace innovative technology for planting and harvesting, and a reduced number of farming activities performed through custom hiring services.

4 Discussion

The study finds that the probability of adaptation to aging significantly increases by 1.2% for each additional year of age in rice farmers. The explanation for this positive relationship is linked to the farmers' awareness of declines in physical strength as they age. This suggests that older farmers are more aware of reductions in physical strength. This manifests in decisions to adapt such as letting their children become more involved in rice farming activities. This finding aligns with that of previous studies [11,12].

Larger farm sizes are associated not only with an increased likelihood of farm succession, as found in the study of Shahzad et al. [12] for the case of Pakistan farmers, but also with a positive relationship to the Thai rice farmer's adaptation of farming practices in response to aging challenges, as found in this study. The explanation is that a large farm size offers better prospects, providing more opportunities for descendants to be involved in rice farming activities. Large farm sizes also provide more space and resources, making it feasible for farmers to diversify into perennial trees or other crops that are less labor-intensive. However, in the case of Thailand, the influence of farm size on the likelihood of adaptation to aging is small, as indicated by a small marginal effect of 0.34. The likelihood of farmers adapting to the challenges of aging significantly increases by 0.34% when there is an increase of 1 ha in farm size. Thus, having a larger farm size may not significantly improve the prospects for descendants to be more involved in rice farming activities, particularly in the context of highly volatile rice prices.

Rice farmers with access to irrigation facilities are approximately 22% more likely to adapt to aging compared to those without access to irrigation. This emphasizes the importance of irrigation access in influencing farmers' decisions to adapt. Access to a reliable water supply offers the potential for increased yields, creating a better prospect for descendants to be more involved in rice farming. This is consistent with the findings of previous studies [10,13], showing that farmers with access to irrigation were more likely to give farmland to children. In addition, improved water availability via irrigation facilities allows farmers to cultivate other less labor-intensive crops that require consistent watering.

Regarding land tenure security, rice farmers with more secure land tenure are more inclined to adjust in response to aging challenges. A one-unit increase in the proportion of securely owned farmland increased the likelihood of adapting to aging by 17.5%. Farmers who own land and have a strong sense of ownership are better

able to adjust their rice farming practices. In contrast, farmers who rent land and have no sense of ownership are less able to adapt their rice farming practices. This is consistent with the findings of Januswan and Zander [10], who found that farmers who intended to continue farming without any changes were renters.

The perception of aging impact on rice production has a significant influence on rice farmers' adaptive decisions. Rice farmers who perceived an impact of aging on rice production are 17% more likely to adapt than those who perceived no impact of aging. The explanation is that rice farmers who perceive an impact are more keenly aware of the effects of aging. This awareness is also linked to their sense of exposure to risk. The more aware the farmers are, the more they understand their exposure to the risks associated with aging such as physical limitations, labor shortage, or a decline in productivity. As a result, farmers who perceive an impact of aging are more likely to engage in proactive risk management, by adopting strategies to minimize those risks. In addition, rice farmers who are willing to learn and embrace innovate technology are approximately 10% more likely to adapt their rice farming practices than those who are unwilling. Farmers who are willing to learn are more likely to acquire new knowledge and adapt to aging by adopting some labor-saving technology. This emphasizes the importance of a positive attitude toward learning and incorporating innovative technologies as significant influences on rice farmers' adaptation. Finally, this study found a significant negative relationship between the number of rice farming activities for which farmers use custom hiring services and the likelihood of rice farmers adapting. As the number of rice farming activities for which farmers use custom hiring services increases by one activity, the likelihood of farmers adapting decreases by almost 8%. Rice farmers using custom hiring services for many rice farming strategies rely extensively on those custom hiring services. This might be due to a lack of labor or a deficit of financial resources to purchase and operate machinery, making it difficult to adopt labor-saving machinery. In addition, when expensive farm equipment is not owned, the descendants may have little incentive to actively participate in rice farming. As a result, rice farmers with a higher reliance on custom hiring services have a reduced ability to adapt to aging, and this is associated with a decreased likelihood of farmers adapting to aging challenges.

Among all the significant variables, the marginal effect of access to irrigation is the largest, followed by land ownership and the perceived impact of aging. This implies that access to irrigation, owning the land, and increasing awareness of the impact of aging have a substantial impact on increasing the likelihood of farmers adapting to aging.

According to previous studies, male farm operators in Pakistan and China are more likely to have a farm successor [12,13]. However, gender does not seem to have a significant impact on Thai rice farmers' ability to adapt to aging. This study suggests that there are no significant differences between male and female farmers in Thailand when it comes to addressing the challenges posed by aging. Additionally, the study found that household size is not a significant factor in predicting farmers' adaptation to aging in Thailand.

Based on the findings of this study, it was observed that the original hypothesis was not supported. The coefficient of land unsuitability and insufficient savings were found to be statistically insignificant in explaining how farmers adapt to aging. Additionally, it was unexpectedly found that rice farmers with insufficient savings are more likely to adapt than those with sufficient savings. This suggests that insufficient savings may be perceived as a financial risk by rice farmers in Thailand, which motivates them to take proactive measures to mitigate potential financial challenges associated with aging rather than being a financial constraint.

5 Conclusion and recommendations

This study presents a comprehensive view of Thai rice farmers regarding the effects of aging on rice farming. It explores the measures they take in response to these challenges and the factors that influence their decisions to adapt. According to the farmers' perception, aging has a minimal impact on rice farming. The most adopted strategy by rice farmers in Thailand is to involve their descendants more in rice farming activities.

The binary probit model results have shown that certain factors such as irrigation, land ownership, and the farmer's perception of the aging impact are major drivers that influence farmers to adapt their practices. This highlights the significance of on-farm irrigation systems and water management, as well as the importance of secure land rights. Farmers should also be made aware of the aging impact to motivate changes in farming practices. Additionally, the willingness to learn and adopt innovative technology are also significant factors that explain rice farmers' adaptation. This emphasizes the importance of a positive attitude toward learning and incorporating technologies. Agricultural extension services and training programs can play a pivotal role in fostering a positive attitude toward learning and technology adoption among farmers. It is crucial to emphasize the benefits of adopting

innovative technology in rice farming and making it more affordable, which would encourage farmers to have a positive attitude toward learning and to adopt relatively more labor-saving machinery. Another factor that significantly influences the farmer's adaptive decision is the use of a custom hiring service. Rice farmers who rely heavily on custom hiring services have a reduced ability to adapt to aging, which is associated with a decreased likelihood of farmers adapting to aging challenges. Policymakers and agricultural extension services may need to address the challenges faced by farmers who heavily depend on custom hiring services. Improving the quality and reliability of custom hiring services, providing training and incentives for service providers to invest in machinery and innovative technology, and making the service more cost-effective could be policy options to mitigate the impact of aging on rice farming for those farmers.

This study suggests that future research should include longitudinal studies to track changes in farmers' adaptation strategies over an extended period. It should also focus on intergenerational farm succession dynamics, with a particular emphasis on the attitudes and preferences of the younger generation toward agriculture.

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Informed consent: All participants involved in this study provided informed consent prior to their participation. They were informed about the purpose of the study, the questions to be asked during the interview, and their right to withdraw from the interview at any time without facing any consequences. Participation in the interview was entirely voluntary, and participants were assured that their personal information would remain confidential and would not be used for any purpose other than research. This study adhered to ethical guidelines, and participants were not exposed to any risks associated with controversial issues that could cause mental or physical harm.

Ethical approval: The approval was informally obtained from the internal committee (Dr. Boonjit Titapiwattanakul, Dr. Somsak Piebprom, and Dr. Somporn Isavilanonda at the Department of Agricultural and Resource Economics, Faculty of Economics, Kasetsart University).

Data availability statement: The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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