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Indigenous farmers' perception of climate vulnerability, barriers and factors influencing farmers adaptation intention: evidence from mountainous area of Vietnam

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Climate change has adversely affected the agriculture of indigenous farmers. Farmers can lessen agricultural losses by using adaptation strategies to climate change. However, the adaptation process depends on several factors, including barriers. This paper examines the farmers' opinion toward adaptation barriers and tries to identify how the barriers influence farmers' adaptation intention. We collected data from 362 randomly selected farmers by using face to face interview method and focus group discussions in Backan province, Vietnam. The severity index technique was applied to calculate farmers' perception of barriers and climate change vulnerability indexes, and we used the probit model to determine the factors affecting farmers' adaptation intention. The results indicate that farmers identified 10 internal factors and 14 external barrier factors that influence the adaptation intention. Moreover, probit model confirmed that farmers' adaptation intention was significantly affected by education level, major occupation, income, lack of technical process, high cost of farm labor, lack of access to pesticides, and lack of technical officers. As a result, climate vulnerability indexes and barriers, and adaptation factors should be considered for designing and performing the policies in the future for indigenous farmers.

KEYWORDS

climate change, adaptation barriers, probit model, indigenous farmers, Backan, Vietnam

Introduction

Climate change has become one of the major challenges to achieving global sustainable development goals. It has already severely affected people's health and food security in rural regions, especially in remote mountainous areas (IPCC, 2014; Wang et al., 2020). A huge body of evidence from previous studies maintained that climate change will continue to be detrimental to people and economies all over the world (Masud et al., 2017; Wang et al., 2020; Antwi-agyei and Nyantakyi-frimpong, 2021). Moreover, climate change will exacerbate certain natural disasters, shifting the frequency, intensity, duration, and timing of many weather-related extreme events (Arouri et al., 2015). As a result, there will be reduced crop yields and productivity, worsening poverty and food insecurity among farmers (Arbuckle et al., 2013). Ali and Erenstein (2017) revealed that, in developing countries, climate change affected most smallholder farmers

and the poor living in the farming regions. Furthermore, in developing countries like Vietnam, the indigenous smallholder farmers are severely affected by climate change. To reduce the adverse impacts of climate change, adaptation practices are the key responses and have been instrumental in reducing the negative impacts of climate change and in increasing the adaptive capacity of farmers (Ali and Erenstein, 2017; Wang et al., 2020). Adaptation is "the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC, 2014; Nkomwa et al., 2014). However, adaptation to climate change includes numerous components including farmers' perception, adaptation strategies, effective factors, and barriers to farmers' adaptation (Esfandiari et al., 2020). Besides, climate change adaptation process took a long time to accomplish, and thus, needs to be managed In systematic complex response steps. Importantly, climate change is often affected by multiple factors such as socio-demographic and institutional factors, and in particular, barriers or limiting factors (Wang et al., 2020).

Adaptation barriers are the key factors that impede farmers from transforming an adaptation intention to a specific adaptation action, which could effectively decrease the climate change vulnerability and increase the adaptive capacity of the farmers (Wang et al., 2019). Several studies have implied that farmer" adaptation actions to climate change were frequently affected by numerous barriers such as lack of financial means, knowledge, skills, and labor, poor access to credit, and poor infrastructure (Moser and Ekstrom, 2010; Archie, 2014; Dang et al., 2014; Abid et al., 2016; Wanjiru Kibue et al., 2016; Masud et al., 2017; Oberlack, 2017; Khanal and Wilson, 2019; Mclean and Becker, 2020; Singh, 2020). Adaptation barriers are displayed not only in the internal limitations of farming households (e.g., lack of knowledge, inadequate income, low skills, lack of labor), but also in constraints from the external environment (e.g., poor infrastructure, lack of government, NGOs supports, lack of access to credit, lack of access to new crops, pesticides, fertilizers, and lack of information as well as early warming information) (Masud et al., 2017; Wang et al., 2019; Singh, 2020). Also, these barriers may fail adaptation to climate change impacts (Moser and Ekstrom, 2010; Wang et al., 2020).

According to IPCC (2014), the terms "barriers," "obstacles," and "limit" are often used as synonyms. In addition, IPCC (2014) reported that "the term constraints were used most for indicating the factors that make it harder to plan and implement adaptation action." Despite this difference, or whether constraints or barriers are used, both terms signify that farmers are prevented from employing effective adaptation mechanisms to climate change. Moreover, Moser and Ekstrom (2010) argued that barriers may impede the climate change adaptation process. Nevertheless, previous studies have indicated that the concepts of "barriers," "limits," and "obstacles" are frequently used interchangeably. Therefore, in this research, "limits" are referred to as obstacles that make adaptation more difficult and tend to be absolute in a real sense. Barriers, in contrast, are defined as obstacles that "can be overcome with concerted effort, creative management, change of thinking, prioritization, and related shifts in resources, land uses, institutions, etc." (Moser and Ekstrom, 2010; Ober and Sakdapolrak, 2020). Furthermore, Klein et al. (2014) reported that adaptation constraints or barriers are factors or progress that cause obstacles in performing adaptation strategies such as few adaptation options, high-performance costs of strategies or programs, or a decrease in the effectiveness of selected responses to reaching adaptation goals. Moreover, the barriers or constraints were reported to be associated with enhancing climate adaptation (IPCC, 2014). It seems that adaptation barriers such as access to resources and technologies have affected the process of decision-making by farmers (IPCC, 2014; Pakmehr et al., 2020). As a result, a better understanding of the barriers is vital for the success of climate change adaptation (Moser et al., 2008). Although previous studies expressed constraints and barriers in a similar way (Burnham and Ma, 2017; Gawith et al., 2020), this research modified these terms to some extent whereby, internal barriers refer to something that emerges from endogenous factors of the households or their adaptive capacity (e.g., no perceived benefits, costly, labor shortage), whereas external adaptation barriers are defined as exogenous factors that restrict households from adaptation process to climate change impacts; for instance, lack of access to credit, poor quality of roads, lack of support from the government.

Barriers to climate change adaptation were investigated in several studies (Moser and Ekstrom, 2010; de Jalón et al., 2015; Singh, 2020). These were viewed as complex factors that affected and hampered adaptation to the impacts of climate change (Tessema and Simane, 2020). More importantly, many barrier factors will impede the adaptation process causing the adaptation process for the farmers less effective, and sometimes, requiring costly changes (Moser and Ekstrom, 2010). Therefore, for its successful implementation by farmers at the local level, particularly those in remote mountainous areas with limited resources and technology, the study on adaptation barriers to address climate change impacts on indigenous farmers is very relevant.

Furthermore, despite the important influence adaptation process of the farmers in many countries, the understanding of factors related to barriers that affected the adaptation process by smallholder farmers is still lacking and neglect (Singh, 2020), particularly in Vietnam. Therefore, the requires exploration of barrier factors that constrain the implementation of the adaptation process is more and more important. This study is set out; to (i) investigate farmers' perception towards identifying the climate change vulnerabilities, and adaptation barriers to decrease climate change impacts, and (ii) examine factors that influence farmers adaptation intention. This research contribute to literature in impirical knowledge in terms of geographical aspects of indigenous farmers' climate change adaptation process, barrier factors, and farmers' perception of climate vulnerability in Vietnam. Particularly, the regression model is first time to use for testing how barriers affected climate change adaptation intention of indigenous farmers. In practical aspects, the results of this study are useful for policy makers, planner, and stakeholders to develop climate change adaptation policies for indigenous farmers.

Conceptual framework

Climate change has adversely affected the agriculture of indigenous farmers in Vietnam (CARE, 2013). Farmers can lessen the negative impacts of climate change on production by taking adaptation strategies to tackle its impacts (Dang et al., 2014). However, the adaptation process depends on several characteristics, including adaptation barriers. In this study, taking adaptation actions may depend on the number of different drivers and factors, such as farmers' perception of climate change vulnerability, and opinion

toward climate change impacts. Therefore, we divide the adaptation process of indigenous farmers into three stages; the perception stage farmers perceive the climate change vulnerability (see Figure 1), and farmers perceived accurate opinion toward adaptation barriers. This stage may also be affected by socioeconomic factors as well as internal and external drivers (Moser and Ekstrom, 2010; Abid et al., 2016; Masud et al., 2017). Farmers will move to the next stage unless understanding the perception stage. In this stage farmers intend to take adaptation strategies to adapt or not may depend on age, education level, income, lack of money, poor market facility, and poor credit facility (Dang et al., 2014; Abid et al., 2019). Then, farmers will decide to take adaptation actions. In this phase, farmers may select a change in crop varieties, changes in crop calender and fertilizer, and off-farm income to address climate change impacts. In reality, farmers, perceived the climate change vulnerability and its impacts on their farms, are not willing to take any adaptation measures, this is because taking adaptation actions depended on several factors not only perception of climate change vulnerability and its impacts but relied on different drivers (e.g., income, lack of labor forces, lack of money). In this case, farmers will not opt any adaptation strategies.

To explore farmers' understanding of barrier factors affecting farmers' adaptation process, we employ a probit model to identify how the barrier factors influence the climate change adaptation process of the indigenous farmers. Given that we first identified dependent variables for the intention adaptation process (see Table 1). Farmers were asked about their intention to take adaptation actions in the future although farmers may face many barriers, if farmers answer yes (1), meaning that farmers will likely intend to take adaptation actions and no (0) otherwise. The explanatory variables include socioeconomic factors, internal and external factors. Socioeconomic factors include education, age of respondents, ethnicity, gender, income, family status. Internal factors include lack of money, lack of knowledge, and farming experience. Ten external barriers factors were also determined; poor market facility, poor credit facility, technical knowledge support in the adaptation process, the high cost of farm labor, lack of water source for irrigation, lack of access to pesticide, poor infrastructure, poor support from local government, NGOs, and lack of technical officers (Deressa et al., 2009; Ullah et al., 2018; Abid et al., 2019; Ado et al., 2019; Karimi et al., 2020). Ethnicity is the category variable. Household size, age, income, and education are continuous variables measured in number. The income variable was measured by asking farmers the total of money the family earned in the year 2018. Family status refers to poor or non-poor families. The rest of the variables are binary and take values of zero and one.

Methodology

The study area

Backan is located between 21^{0}48′ and 22^{0}44' N, 105^{0}26′ and 106^{0}15′ E in the northern mountainous region which is most vulnerable to climate risks including landslides, flash floods, heatwaves, and cold spells. Backan is one of the poorest provinces in Vietnam with a large diverse indigenous population, high illiteracy rate, low female education attendance, poor access to resources, and an economy that heavily depends on rainfed-agriculture (Smyl and Cooke, 2017). Backan has number indigenous groups living together including Tay, Thai, H.mong, Daos. Of which Tays people accounts for 45%, while H.mongs and Daos accounts for 20, and 21%, respectively, and others are 14%. The highest temperature is around 41.1°C was recorded in 2019. Lowest temperature is -1°C in 1974. Mean temperature in Backan was 22.40°C. The average of rainfall in Backan was 1,042 mm to 2,114 mm/years (Backan meteorological data, 2019).

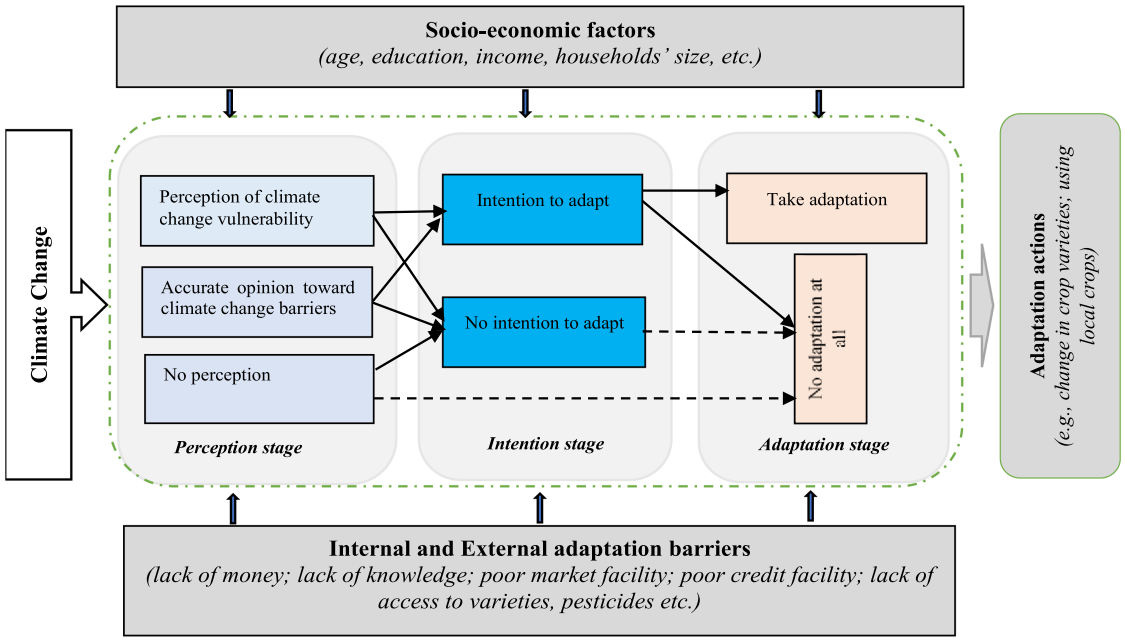

FIGURE 1
Conceptual framework of the research.

TABLE 1 Dependent and independent variables for the models (n=362).

Variable	Description	Mean/%	SD
Socio-demographic factors			
Ethnicity	Tay farmer = 1	57.2%	–
	H.mong farmer = 2	26.8%	–
	Dao (Yao) farmer = 3	16.0%	–
Households' size	The number of members in the households, scale	4.12	1.29
Gender	Gender of respondent, dummy	0.88	0.33
Age	Age of household head, scale	45.9	12.3
Education	The years of education of farmers, scale	7.59	3.33
Major occupation	1 if respondents' job relied on agriculture, 0 otherwise	0.88	0.32
Income	Households' income in the year 2018 (million dong)	49.95	32.82
Family status	1 If households are poor, 0 otherwise	0.57	0.49
Internal adaptation barriers			
Lack of money	Lack of finance capital, dummy	0.78	0.42
Lack of knowledge and farming experience	Farmers lack knowledge and experience to apply, dummy	0.74	0.43
External adaptation barriers			
Poor market facility	Farmers do not have access to the market, dummy	0.88	0.33
Poor credit facility	Farmers lack access to formal credits, dummy	0.72	0.45
Technical knowledge support in the adaptation process	Technical knowledge and facility support to apply adaptation measures, dummy	0.67	0.47
The high cost of farm labor	Labor cost was high, dummy	0.82	0.38
Lack of water source for irrigation	Lack of water source for irrigation system, dummy	0.64	0.48
Lack of access to crop varieties	Lack of new crop varieties, dummy	0.67	0.47
Lack of access to pesticides	Lack of access to pesticides and chemical, dummy	0.71	0.45
Poor infrastructures	Poor infrastructures, dummy	0.77	0.42
Poor support from local government, NGOs	Lack of support from local government, NGOs, dummy	0.65	0.47
Lack of technical officers	Lack of technical officers, dummy	0.65	0.47
Dependent variable			
Adaption intention	Farmers intend to apply adaptation, dummy	0.62	0.48

1USD = 23,000 Vietnam dong at the time conducting research. We used Stata 15 software to analyze the data in this research.

In order to achieve the objectives of study, we chose Backan to be a study area. Then, a multistage sampling technique was used for this study. Three districts namely Chomoi, Pacnam, and Nganson districts were randomly selected from 7 total district in Backan province as the study area with regional topography which is generally mountainous; small plain areas thinly located between valleys and along the large rivers, and highly vulnerable and influenced by climate change impacts and natural disasters (CARE, 2013). Then, in each district, we purposively selected three communes to collect data; Mailap in Chomoi, Langngam in Nganson, and Ngienloan in Pacnam, based on the main characteristics such as high ethnicity ratios, differently located regions, particularly highly influenced by climate change impacts. A simple random sampling technique was applied for primary data collection at the household level (Figure 2).

Data collection

This study used the survey method and focus group discussions (FGDs) to collect the data. We developed the questionnaire using open and closed questions, prepared in English at first, and then translated into Vietnamese. The questionnaire was also pretested to avoid errors. The questionnaire mainly covered farmers' perception of climate change vulnerability, opinion toward climate change barriers, adaptation intention, and influential factors. The data were collected by a research team involving four research assistants and three local officers who were led by the first author of this research. The research team members were trained regarding the research areas and on how to collect data properly. Based on the random selection of households, head of households were selected for a face-to-face interview. Before

the interview, definitions of the concepts related climate change vulnerability, adaptation to climate, opinion toward climate change impacts, and its interpretations were explained to farmers for avoiding misunderstood during the interview.

Focus group discussions

We conducted a total of six FGDs with 8–12 mixed-gender participants. Farmers who were selected for FGDs had a minimum age of 40 and at least 20 years of farming experience. The FGDs progressed in four steps including design and preparation, farmer recruitment, implementation, and data analysis. Indigenous farmers were asked about topics related to climate change perception, change in weather, temperature, rainfall, drought, natural disasters, adaptation intention and practices, climate change vulnerability, climate change impacts, opinion about climate change impacts, and barrier factors. The topics were reviewed to ensure clarity and relevance. The discussion topics were prepared in one and a half to two hour long discussion sessions.

Sampling procedure

A multistage sampling technique was used for this study. First, three districts namely Chomoi, Pacnam, and Nganson in Backan province were randomly selected as the study area with regional topography which is generally mountainous; small plain areas thinly located between valleys and along the large rivers, and highly vulnerable and influenced by climate change impacts and natural disasters (CARE, 2013). Then, in each district, we purposively selected three communes to collect data; Mailap in Chomoi, Langngam in Nganson, and Ngienloan in Pacnam, based on the main characteristics such as high ethnicity ratios, differently located regions, particularly highly influenced by climate change impacts. A simple random sampling technique was applied for primary data collection at the household level. The fieldwork was conducted from June to October 2019. About 400 household heads were interviewed for data collection based on the formula (1) of Yamane (1967), and Saqib et al. (2016). Finally, a total of 362 respondents provided complete information with a 95% confidence level and ± 7% margin of error.

$$n = \frac{N}{1 + N^{*}(e)^{2}} \quad (1)$$

n = sample size.
N = Total population;
e = Level of precision, set at ±7% at 95% of confidence.

Analytical methods

Measuring perception of climate change vulnerability

To measure the perception of climate change vulnerability, we adapted the Severity Index (SI) technique from previous studies of Majid and McCaffer (1997), Isa et al. (2005), and Masud et al. (2017). This technique is used to measure farmers' opinion of adaptation barrier factors that affected the adaptation process and it is also used to measure indigenous farmers' perception of climate change vulnerability. SI has been widely used by several scholars to measure the strength of respondents' opinions and perceptions in many other fields of study. In this research, rather than simply calculating the percentage and mean value of respondents based on disagree and agree ratios or proportions SI technique was most appropriately used to attempt to explore indigenous farmers' opinions toward the climate change vulnerability, and barrier perceptions. Respondents indicate their responses on a 5-point Likert Scale (1 farmers strongly disagree of climate change impacts

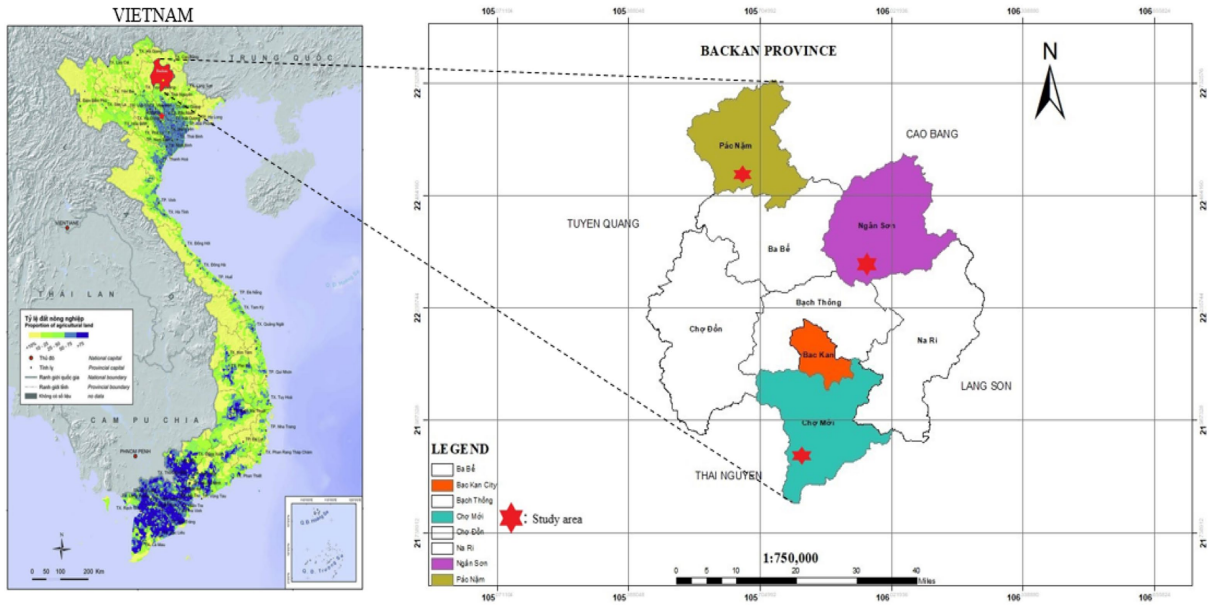

FIGURE 2
Map of the study area. Sources: designed by the authors.

to 5 strongly agree of climate change impacts). The SI will compute the following equation as bellow;

$$\text{Severity Index}\left(SI\right)=\left(\frac{\sum_{i}^{4}pi.qi}{4\sum_{i=0}^{4}qi}\right)x100\% \quad (2)$$

Where; *pi* indicates the index of a class of indigenous farmers' perception or opinion on climate change issues, the constant denotes the weight assigned to the class, while *qi* denotes the frequency of response of farmers, that is $i = 0, 1, 2, 3, 4$, as shown below. In addition, p_0, p_1, p_2, p_3, p_4 represents the response frequencies corresponding to $q_0 = 0$, $q_1 = 1$, $q_2 = 2$, $q_3 = 3$ and $q_4 = 4$. Hence, the valuation arrangement followed Majid and McCaffer (1997) is as follows:

1	Least impact	$q_0 = 0.00 \leq SI < 12.5$
2	Less impact	$q_1 = 12.5 \leq SI < 37.5$
3	Moderate	$q_3 = 37.5 \leq SI < 62.5$
4	Impact	$q_2 = 62.5 \leq SI < 87.5$
5	Strongly impact	$q_4 = 87.5 \leq SI \leq 100$

Assessing the factors related to adaptation intention

Binary probit regression

The effectiveness of adopting climate change adaptation strategies depends on many factors which may be internally from households and the external environment. Farmers decide to adapt based on their adaptive capacity (e.g., human capital, financial capital) and multiple other factors (e.g., climate information services, policies, and market access). Previous studies reported that farmers' decision to adapt was influenced by sociodemographic, institutional, social, and psychological factors as well as adaptation barriers (Dang et al., 2014; Arbuckle et al., 2015; Ali and Erenstein, 2017; Abid et al., 2019; Pham et al., 2019). Several previous studies have investigated the factors affecting farmers' decision to adapt to climate change, but only a few studies analyzed the impacts of adaptation barriers in influencing farmers' adaptation intention and the extent to which they are affected. To address this limitation, this research examined how the farmers' adaption intentions were impacted by certain constraints. Generally, researchers make use of the descriptive method to study the influence of adaptation barriers on farmers' adaptation to climate change (Bryan et al., 2009; Dang et al., 2014; Simonet and Leseur, 2019; Karimi et al., 2020). However, investigated the same topic using the regression model is scarce. Furthermore, the factors shaping the farmers' adaptation intention to climate change were determined using various methods as shown in the literature (Ali and Erenstein, 2017; Ado et al., 2019) such as the use of ordinal and nominal logistic regressions, binomial probit model, and logit model. In this research, probit model is used and farmers were queried about their adaptation intentions in relation to the changing climatic conditions after clarifying the barriers that they may face in the future. The probit model is the appropriate statistical method when the dependent variable is a binary outcome (Bryan et al., 2009; Saqib et al., 2016; Islam et al., 2020), and the independent variables are either metric or nonmetric (Hair et al., 2010). It provides not only a measure of how appropriate a predictor (coefficient size) is, but also the direction of the association. Moreover, the binary probit regression model can measure the outcome of farmers' intention to adapt to climate change because of the decision variable, which represents the farmers' tendency to carry out the adaptation strategies despite the barriers or their perceived impacts of these constraints. Furthermore, the binary probit model considers the relationship between a binary dependent outcome; that is, if farmers answered yes (1), which means that farmers were likely to undertake the adaptation strategies to climate change, but if they answered no (0), indicating that they will not adopt the strategies. The model also incorporated a set of independent variables, whether they are binary, categories, or continuous (Bryan et al., 2009; Abid et al., 2016, 2019; Ado et al., 2019). Furthermore, Jewell (2004) and Paudel and Pant (2020) suggested that the binary probit regression model is better utilized for the binary outcome than the logit model, and it is simple to perform, in explaining, and interpreting the results. The formula for the binary probit model (Bryan et al., 2009; Saqib et al., 2016; Fahad et al., 2020; Islam et al., 2020) is given as:

$$Y = \beta 0 + \beta iXi + \varepsilon \quad (3)$$

where *Pi* is the probability of intention to adapt to climate change and *Xi* is an independent variable. The parameter βi is a vector of regression coefficients of the dependent variables to be estimated, and β_0 is a constant. The marginal effect for the *i*th variable is given by the equation (Thoai et al., 2018; Esfandiari et al., 2020).

$$\frac{\delta\left(y=1\right)}{\delta Xi}=\delta\left(\beta x\right)+\beta i \quad (4)$$

where ∂ is the cumulative normal density function. Therefore, in this case, the marginal effects were calculated by:

$$\Delta P\left(y=1\right)=\delta\left(\beta 1\right)-\delta\left(\beta 0\right) \quad (5)$$

Dependent and explanatory variables

Table 1 illustrates the dependent outcome and independent variables. The explanatory variables have either directly or indirectly influenced farmers' adaptation intention to climate change (Ali and Erenstein, 2017; Abid et al., 2019). In particular, the variables affected the farmers' decisions in their application of the adaptation strategies despite facing some constraints in adapting to them. Therefore, it is important to take into account relevant factors in relation to adaptation barriers. To examine the factors affecting farmers' intention to adapt to climate change impacts, this study assumed that the farmers' adaptation intentions were influenced by socioeconomic variables and explanatory variables (i.e., internal and external adaptation barriers) listed in Table 1. The sociodemographic factors include ethnicity, family status, gender, education, farm size, etc., while endogenous adaptation barrier factors consist of lack of money, lack of knowledge, inadequate skills, and lack of experience. External adaptation barriers, in contrast, cover poor market facility, poor credit facility, lack of technical process facility, lack of water source for

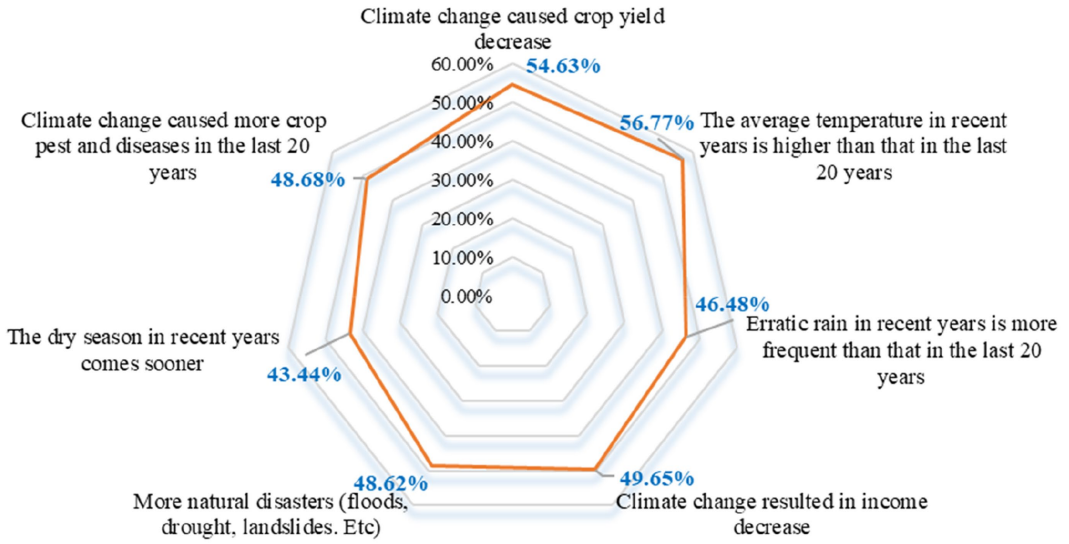

FIGURE 3
Farmers' perception of climate change vulnerability (n=362). Source: field survey, 2019.

irrigation, poor support from local government, NGOs, and poor infrastructures; these factors were established in several past studies (see Bryan et al., 2009; Deressa et al., 2009; Dang et al., 2014; Ullah et al., 2018; Abid et al., 2019; Ado et al., 2019; Islam et al., 2020; Karimi et al., 2020). Due to limitation of time and avoid sensitive and insignificant variables, some variables were missing (e.g., farm size, women's access). Further study will consider these factors.

Results and discussion

The socio-economic features of the indigenous farmers

From a total of 362 interviewed households, 31.5% of the respondents were from Mailap, 42.5% were from Langngam, and 26% came from Nghienloan. In terms of gender, 87.6% were male, while the female was 12.4%. The average age of the indigenous farmers was 45.9 years, and the mean of household members was 4.12. Regarding farming experience, 58.6% of the respondents had over 15 years, 29% of the respondents had 5 to10 years, and 12.5% of them had from 3 to 5 years. For education level, 44.2% of the respondents completed secondary school level, 29.8% was the primary level, 13.3% had high school level, while college graduate respondents were 4.7% and a few of the respondents (8%) never attended school. In terms of poverty, about 38.4% of the households were poor; 20.7% were near-poor; whereas, 32% of the households had average economic conditions and 8.8% had good economic conditions.

Farmers' opinions of climate change vulnerability

To take adaptation actions, farmers must notice climate change vulnerability (see Figure 3); therefore, rating the relative importance of the challenges reported by farmers was calculated, farmers were asked to measure the severity level of the climate change vulnerability using the 5 Likert scale, and then, the SI was calculated. The SI values are shown in Figure 1. The results indicate that the SI values are associated with the farmers' perceptions of climate change vulnerability, having values between 43.44 and 56.77%, indicating that indigenous farmers were aware of their vulnerability to climate change at a moderate level based on the valuation agreement created by Majid and McCaffer (1997). Farmers have also witnessed the highest vulnerability to climate change in the form of average temperature increase in recent years compared to the last 20 years. Another observation by the farmers was "the decline in crop yield due to climate change" with an SI value of 54.63% and ranked second in the vulnerability level. This means that climate change is certainly happening with negative consequences in agriculture. Climate change has also resulted in a decline in household income as confirmed by the farmers, with an SI value of 49.5%. Moreover, more natural disasters, unpredictable rain, sooner-than-normal dry season, and an increase in the number of crop pests and diseases also perceived by farmers as caused by climate change with SI values between 43.4 and 48.7%. The findings confirmed the results of Masud et al. (2017).

Adaptation strategies to climate change impacts

Investigating whether farmers decide to apply adaptation strategies to address the impacts of climate change in the future or not plays an important role in development of policies. Therefore, discussions with farmers were performed regarding the impacts of barriers, barriers information, and knowledge on how barriers affected the adaptation process. Then, farmers were asked about their plan to undertake various adaptation strategies to lessen climate change impacts in the next season as well as the actual adaptation strategies that farmers applied. The improved crop strategy (e.g., using short duration crops, resistant and tolerant crops) was the most popular adaptation strategies accounted for 79.8%. A similar result was also found in the study of

Abid et al. (2016). About 71% of the farmers used changing fertilizer types and changing the time of fertilizer application to cope with climate change impacts and 70.4% of the farmers generated more income from off-farm activities such as wage labor and opening a small business, these results were in line with previous findings of Piya et al. (2013), Alemayehu and Bewket (2017), and Fadina and Barjolle (2018). However, it was inconsistent with the result of Nkuba et al. (2020) who indicated that arable farmers in mountainous regions were less likely to generate non-farm income. We also found that 68% of the farmers used local crops as an adaptation strategy, this finding was reported by Son et al. (2019). About 47% of the farmers took loan to lessen climate change impacts, and 37.6% of the farmers diversified their crops, while 32.3% of the farmers used livestock, fishing as the coping strategies, respectively. It was also reported in the previous studies of Fadina and Barjolle (2018). Approximately 23.8% of the farmers migrated out of their village to search alternative livelihoods and send money back to home as an adaptation strategy (Alam et al., 2017; Jha et al., 2018). Importantly, indigenous farmers were asked their likelihood to adopt adaptation strategies, our findings show that 62.4% of the farmers stated that they intend to adopt the adaptation strategies to deal with climate change impacts although they perceived there are many barriers. Meanwhile, 37.6% of the farmers indicated that they could not, this could be that to take adaptation actions, farmers depend several factors (Figure 4).

Farmers' perception of adaptation barriers

Climate change adaptation could be confining and challenging when farmers face barriers and constraints such as high-cost of labor, lack of farm input, inadequate finance, insufficient water resources, poor access to market and information, lack of field officers, and inadequate credit facilities (Masud et al., 2017; Karimi et al., 2020). Moreover, adaptation process varied between regions, countries, and types of barriers. However, researchers often treat various barriers as denoting the same meaning as limits, so these two are referred to interchangeably (Moser and Ekstrom, 2010). In this research, we focus on the factors related to adaptation barriers that were classified into socioeconomic factors which cover education, age, ethnicity, household size, and internal and external adaptation barrier factors. Based on the objective of the study, farmers were probed about their perception of intention to adopt adaptation strategies, perception of internal factors related to adaptation barrier, and farmers' perception of external factors. The findings of the survey are presented in Figures 5, 6.

Farmers' perception of internal barriers

To meet the objective of the research, the farmers' perceptions of endogenous adaptation barriers were assessed as shown in Figure 5. Besides the socioeconomic factors that influence farmers' adaptation intention to climate change, 10 internal adaptation barriers were revealed in the study area during the survey. About 79.3% of the farmers also mentioned that the adaptation strategies were difficult to apply while 77.3% of the farmers indicated that the strategies were complicated to use. Around 77% of the farmers disclosed that lack of money had affected their adaptive capacity to adopt climate change adaptation strategies. Furthermore, many industrial zones have been built in recent years, resulting in a decrease in the agricultural labor force. As mentioned by 76.8% of the farmers, they were unable to employ workers for their farms which indirectly affected the climate change adaptation process. Another barrier pointed out during the survey with the farmers (76.8%) was that some strategies were expensive, preventing them from carrying out the adaptation strategies.

Moreover, several farmers did not see the benefit of adaptation strategies (69.3%) while 72.4% stated that some strategies were not suitable for their current situation. Another constraint for some of the farmers was their lack of skills and experience while for some, distrust, denials, and disincentives affected the effectiveness of the climate change adaptation process. The results are consistent with the previous findings of Wanjiru Kibue et al. (2016). Although the adaptation barriers have affected the process of adaptation, it is important to bear in mind that "overcoming all barrier factors does not necessarily lead to a successful outcome" (Moser and Ekstrom, 2010).

Farmers' perception of external barriers factors

The farmers surveyed were asked to evaluate their perception of exogenous adaptation barriers as shown in Figure 6. Fourteen (14) types of adaptation barriers were identified. Similar results were found in other studies (Dang et al., 2014; Masud et al., 2017; Khanal and Wilson, 2019). In this study, the poor market facility was

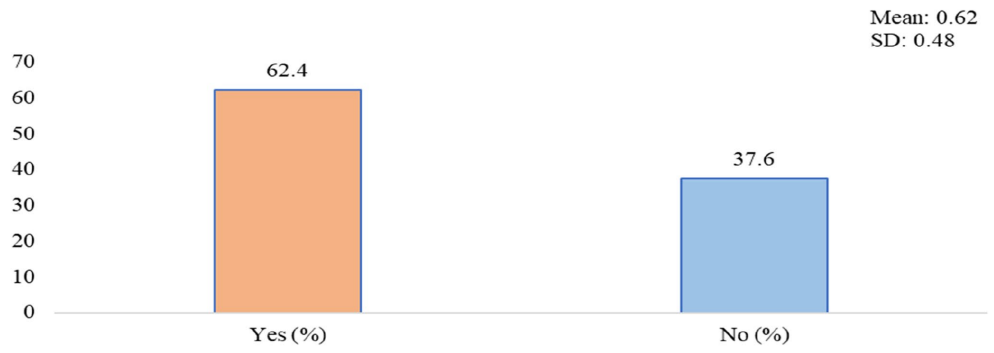

FIGURE 4
Farmers intend to adopt adaptation strategies (n=362). Source: field survey, 2019.

identified as the most important impediment to the adaptation process for about 87.8% of the farmers. This was followed by the high cost of hiring farm laborer as indicated by 82% of the farmers. Furthermore, unavailability of pesticides, poor credit facility, lack of family workers, absence of land ownership, and fragmented land were also some of the limiting factors that directly or indirectly affected the adaptation process to climate change by the farmers (71%). Figure 6 also displays other adaptation barriers that the indigenous farmers were facing; lack of water for irrigation (64.1%), lack of information (64.1%), poor quality of irrigation system (64.4%), lack of support from local government and NGOs (64.9%), lack of technical offices (65.2%), lack of access to crop varieties (66.6%), and poor technical processing facility (67.4%).

During the focus group discussion, some farmers indicated that they failed to adapt although they had access to information or adequate finances. The main reason could be the lack of favorable conditions like adequate techniques, crop varieties, or skills despite having sufficient information and farm input. Our findings are consistent with the previous studies by Shackleton et al. (2015) and Ochieng et al. (2017).

Factors influencing farmers' adaptation intention to climate change

To determine the factors affecting farmers' intention to adapt, probit regression model was used to analyze the data in this research.

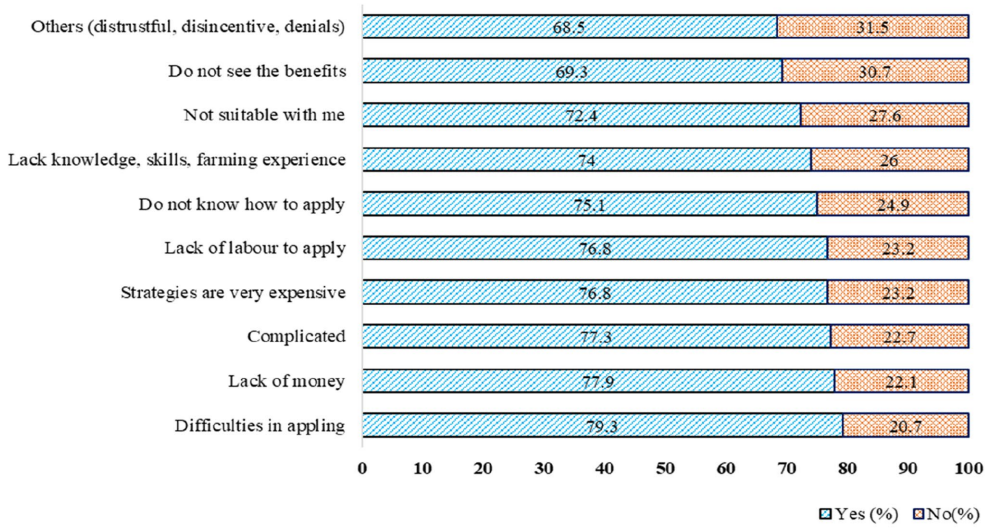

FIGURE 5
Farmers' perception towards internal adaptation barriers (n=362). Source: field survey, 2019.

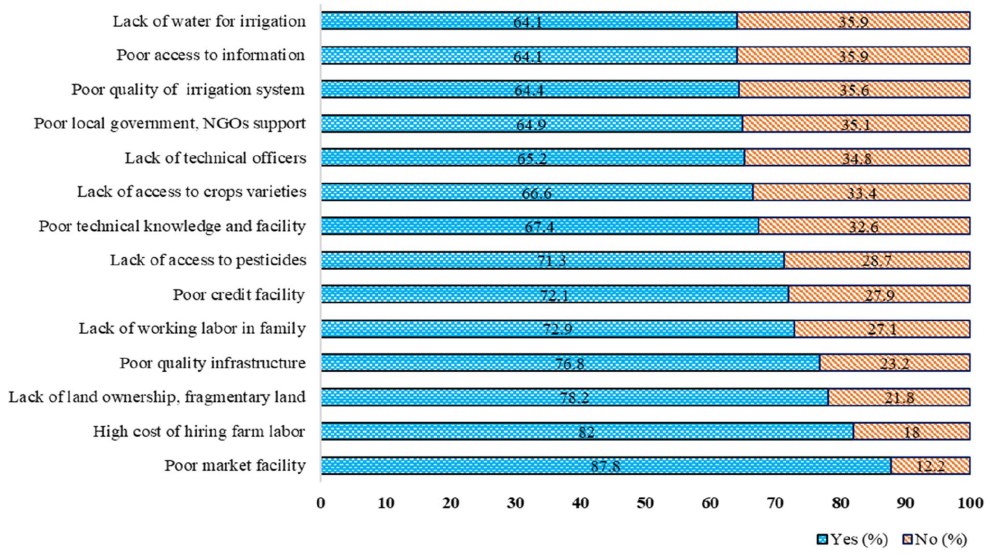

FIGURE 6
Farmers' perception toward external adaptation barriers (n=362). Source: field survey, 2019.

Before performing the probit regression model, multicollinearity and heteroscedasticity issues were tested. The findings show that the mean VIF (variance inflation factor) was 1.432 for all variables in the model, reporting that multicollinearity is not an issue. Moreover, White's test for homoskedasticity was employed, and the result shows that heteroscedasticity was also not a problem [chi2(256) = 263.43, and Prob > chi2 = 0.3615] (Pham et al., 2019). Furthermore, the probit regression model included 22 explanatory variables, and the outcome of the model with regard to farmers' intention to adopt the adaptation strategies to cope with climate change impacts was the value of 1 if farmers intended to undertake the adaptation practices, and 0 if otherwise. The result of the probit model was highly significant with the values of Pseudo r-squared = 0.16, and Prob > chi2 = 0.000. The marginal effects and estimated results of the probit model are presented in Table 2.

Socio-demographic factors

The findings of the probit regression model indicated that among eight socio-demographic factors, five of them significantly affected farmers' intention to adapt to climate change impacts. Those people who belonged to the H.mong ethnic group were more significantly associated with farmers' intention to adapt with a 14.4% higher probability compared to that of the Tay people. The reason could be that H.mong farmers who often lived at the highest altitude are the poorest and faced many constraints in the area, and needed support to overcome their difficulties. Thus, they tried to use adaptation strategies as much as possible to address climate change impacts. This finding is similar to Pham et al. (2020) whose findings indicated that indigenous farmers often settled in remote regions with inadequate infrastructure and poor educational facilities. Also, the livelihood activities of indigenous farmers generally depend on agriculture which is severely affected by natural disasters. Hence, indigenous people paid high attention to cope with the negative impacts of climate change. However, the regression analysis did not reveal any evidence that Dao farmers were significantly correlated with farmers' adaptation intention to climate change.

Education plays an important role in the adaptation intention of the farmers. As can be inferred from the results, farmers with high educational levels are more likely to intend to adapt to climate change than those with a basic educational level (Deressa et al., 2011). Therefore, it is viewed that education could be a key component for building policies. This study revealed that a farmer's level of education positively affected his adaptation intention to climate change. The estimated marginal effect also shows that the probability of farmers' adaptation intention increased by 1.8% if farmers increase a year of education level with other factors constant. Our finding is in line with previous results of Abid et al. (2019) who indicated that educational level positively and significantly affected farmers' decision to opt for adaptation strategies to tackle the impacts of climate change in Bangladesh. However, this is not similar to the findings of Pham et al. (2019), which illustrated that the farmers' decision to adopt adaptation strategies was negatively affected.

Major occupation refers to the main sources of income of the households. Analysis of the survey data demonstrates that the major occupations of farmers positively and significantly affected their adaptation intention. Thus, respondents whose job depends on agriculture, tend to carry out more adaptation strategies to deal with climate change impacts. Also, the marginal effect indicates that the probability of intention to adapt increased by 14% if farmers' livelihood is based on agriculture with other factors constant. Similarly, the findings of Devkota et al. (2018) illustrate that the Nepalese rice farmers' main occupation had affected their adoption of the measures.

Income is another significant factor that caused farmers to adapt to climate change. Data analysis using probit model shows that income positively and significantly influenced farmers' adaptation intention. This implies that households that earn more are more likely to adapt to climate change which is consistent with the findings of Masud et al. (2017). In contrast, family status had a negative and significant impact on the adaptation intention of farmers. Poorer households are likely to adopt adaptation strategies to address the impacts of climate change with other factors constant, at 13.4%. This is because poor households are reliant more on farm activities and are normally lacking in financial means, cropland, skills, or knowledge to invest in their farm. This is similar to the earlier findings of Abid et al. (2016) and Ullah et al. (2018).

Internal factors affecting farmers' adaptation intention

Analysis of the data illustrates that indigenous farmers in this study area faced multiple barriers. Among these internal factors related to adaptation barriers, lack of money and lack of knowledge were also revealed in several studies, and are considered important factors that prevented the adoption of climate change adaptation strategies by farmers (Moser and Ekstrom, 2010; Archie, 2014; Abid et al., 2016; Masud et al., 2017; Oberlack, 2017). In this study, the probit model demonstrates that lack of money, lack of knowledge, and inadequate farming experience negatively and insignificantly affected farmers' adaptation intention to cope with climate change impacts. This is because when farmers experience financial constraints and have inadequate knowledge, they may often fail to improve their farms. It also may infer the fact that there are some constraints faced by farmers such as the inefficiency of the microcredit or financial sector, and lack of extension and technical support for indigenous farmers from local government officers to adapt to climate change. The same finding was revealed in the study of Ifeanyi-Obi et al. (2017) and Wang et al. (2019).

External factors affecting farmers' adaptation intention

Out of 10 exogenous factors that are related to adaptation barriers, five factors show a significant impact on farmers' adaptation intention to climate change. Technical knowledge support in the adaptation process positively and significantly constrained farmers' adaptation intention, indicating that when farmers receive assistance to improve their technical know-how during the adaptation process, their intention increases. The estimated marginal effect showed that the probability of adaptation intention of the farmers increases by 13.2% when technical knowledge support in the adaptation process increases one unit, holding other variables constant.

Another limiting factor, lack of access to pesticides and poor-quality infrastructure, also demonstrated a positive and significant influence on the farmers' intention to undertake adaptation strategies. This illustrates that farmers who lived in a commune with poor quality infrastructure and with even limited access to pesticides are

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TABLE 2 Adaptation barriers affecting farmers' intention to adapt.

Variables	Probit model		Marginal effect	
	Coef.	St.Err.	Dy/dx	Std.Err
Constant	−0.456	0.687	–	–
Socio-demographic factors				
Ethnicity based Tay	0	–	–	–
H.mong	0.468**	0.237	0.144**	0.070
Dao	0.226	0.226	0.072	0.071
HH size	0.035	0.061	0.011	0.019
Gender	0.041	0.220	0.013	0.069
Age	−0.012	0.007	−0.004*	0.002
Education	0.057**	0.027	0.018**	0.008
Major occupation	0.445*	0.246	0.140*	0.077
Income	0.007*	0.004	0.002*	0.001
Family status	−0.424**	0.189	−0.134**	0.059
Internal adaptation barrier factors				
Lack of money	−0.087	0.197	−0.028	0.062
Lack knowledge and farming experience	−0.241	0.184	−0.076	0.058
External adaptation barrier factors				
Poor market facility	−0.062	0.242	−0.020	0.076
Poor credit facility	0.227	0.184	0.071	0.058
Technical knowledge support in adaptation process	0.42**	0.204	0.132**	0.063
High cost of farm-labor	−0.574***	0.210	−0.181***	0.065
Lack of water source for irrigation	−0.200	0.179	−0.063	0.056
Lack of access to crops varieties	−0.171	0.201	−0.054	0.063
Lack of access to pesticides	0.393**	0.195	0.124**	0.060
Poor quality infrastructure	0.678***	0.212	0.213***	0.064
Poor local government, NGOs support	0.184	0.177	0.058	0.055
Lack of technical officers	−0.379**	0.176	−0.119**	0.054
Pseudo *r*-squared		0.160		
Chi-square		69.026		
SD dependent var.		0.485		
Number of observations		362		
Prob > chi2		0.000		
Akaike crit. (AIC)		446.695		

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

more likely to adapt. Access to pesticides and quality infrastructure are important for farmers as this enables them to invest in their farms. The statistical analysis shows that the probability of adaptation intention of the farmers increases by 12.4% for one unit increase in the lack of access to pesticides with other factors constant. Similarly, the probability of adaptation intention of the farmers grows to 21.3% if one unit of poor-quality infrastructure increases with other factors constant. These findings are consistent with the previous result of Archie, (2014), Masud et al. (2017), and Wang et al. (2019). Meanwhile, lack of access to crop varieties showed a negative and insignificant correlation with farmers' intention to adapt.

The high cost of farm-labor and lack of technical officers negatively and significantly affected farmers' adaptation intention to climate change. This suggests that the fewer the households that face the high cost of farm-labor, the less likely they are to carry out various adaptation measures to climate change. The reason could be that inadequate financial resources and a high cost of farm labor are often experienced by farmers in rural areas, resulting in the farmers'

reduced the adoption of adaptation strategies. The estimated marginal effect also reported that the probability of adaptation intention of the farmers reduces one unit if the high cost of farm-labor decreases by 18.1% with other factors constant. This result is similar to the previous finding of Singh (2020), who reported that households that faced acute labor shortage and lack of financial means and income to hire farm labor may not opt for adaptation measures. Similarly, technical officers are important in transferring technology to farmers as the application or implementation of new agricultural technologies and programs requires the expertise of technical officers as well as their understanding of the constraints in the area, particularly in relation to climate change. Previous studies also reported that the lack of technical officers was a major deterrent for farmers in undertaking the adaptation measures (Masud et al., 2017; Wang et al., 2019). This is supported by the results in this study which highlighted the negative and significant impact of lack of technical officers on the farmers' adaptation intention. Also, the marginal effect indicated that the probability of adaptation intention of the farmers reduces one unit if the lack of technical officers decreases by 12% with other factors constant.

A huge body of evidence in the literature points to the fact that market access, credit facility, water sources, and support from government and NGOs are the major factors that influence farmers during the application of adaptation strategies to tackle climate change impacts (Moser and Ekstrom, 2010; Abid et al., 2016; Masud et al., 2017; Khanal and Wilson, 2019; Mclean and Becker, 2020; Singh, 2020). However, in this study, no evidence could be obtained that would demonstrate the significant effects of the factors on the farmers' adaptation intention.

Conclusion

The perceptions of indigenous farmers on climate change vulnerability, and socioeconomic, internal, and external factors related to adaptation barriers were examined. Severity index technique, and probit model were applied to analyze the data and determine how factors affecting farmers' adaptation intention to deal with the impacts of climate change. Farmers noticed climate change vulnerability at a moderate level, and most farmers perceived the higher average temperature in recent years compared with the last 20 years. Both internal and external barrier factors have affected farmers to adapt to climate change. About 79.3% of the farmers noticed that "the adaptation strategies were difficult to apply" as the barriers most impact on the adaptation process, while 87.8% of farmers identified that "the poor market facility" negatively affected on the adaptation process as well. Besides, results from probit model revealed that many factors significantly affected farmers' adaptation intentions such as education, major occupation, income, and family status but we did not find statistically significant evidence of internal factors related to barriers affecting farmers' adaptation intention even though farmers have noticed that factors affected their adaptation process. However, five out of 10 external factors significantly affected farmers' adaptation intention including "lack of technical process," "high cost of farm labor," "lack of access to pesticides," and "poor quality infrastructure," and "lack of technical officers." Our results provide the impirical evidences of both internal and external adaptation barriers that affected farmers's adaptation intention to climate change. Therefore, policymakers should consider these adaptation barriers during designing and implementing the policies for indigenous farmers in the future. Also, adaptation barriers should be considered with appropriate intervention to enhance the local adaptive capacity in the future process of adapting to climate change. Farmers and policymakers, however, should also notice that even overcoming all barriers does not guarantee to lead to a successful adaptation process. Finally, this research also contributes to the literature in terms of using a regression model to determine how factors affect farmers' intention to adapt to climate change.

Data availability statement

The original contributions presented in the study are included in the article/supplementary materials, further inquiries can be directed to the corresponding author.

Author contributions

NM: conceptualization, drafting, data collection, research design, analyzing, methodology, writing. MA: conceptualization, methodology, revising, investigation, review & editing. IP: conceptualization, writing, review and editing. TN: conceptualization, methodology, revising, reviewing, checking and editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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