Heliyon 10 (2024) e31792

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Adoption of sustainable farming practices in Vietnam: A discourse of the determining factors

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A R T I C L E I N F O

Keywords:
Sustainable agriculture
Behavioral factors
Non-behavioral factors
Sustainable livelihood capitals

A B S T R A C T

To delve into the intricacies of sustainable agricultural practices, our study investigates both the behavioral and non-behavioral factors influencing farmers' decision-making processes. Employing the New Ecological Model (NEP) to capture social factors, our research framework integrates insights from the sustainable livelihood framework, which delineates five crucial types of livelihood capital: (1) human capital, (2) natural capital, (3) financial capital, (4) physical capital, and (5) social capital. This comprehensive approach enables us to incorporate additional non-behavioral factors and their impacts on farmers' decisions. We underscore the pivotal role of farmers' decisions in fostering sustainable agriculture, aligning with seven of the Sustainable Development Goals (SDGs). Leveraging survey data collected from 303 Vietnamese farmers, we validate our research framework using two analytical models: Structural Equation Model (SEM) and binary logit analysis. Our findings underscore the significant influence of farmers' risk propensity and concerns regarding food safety and environmental conservation on the adoption of organic farming practices. Notably, farmers' level of knowledge emerges as a critical determinant shaping their inclination towards sustainable agriculture. The study underscores the importance of targeted educational initiatives and awareness campaigns, identifying key determinants such as proximity to green spaces and farm size in shaping farmers' choices towards sustainable practices.

1. Introduction

The agricultural sector is currently grappling with heightened food demand driven by global population growth, yet numerous challenges threaten our ability to meet these needs both now and in the future. While highly intensive agricultural practices are readily accessible, they pose significant threats to the sustainable development of agriculture *(Antle & Diagama, 2003;* [,1,2]*)*. These challenges encompass climate change, soil degradation, salinity intrusion, water pollution, dwindling farm numbers, and the associated issues of poverty and rural depopulation. Agriculture not only confronts these challenges but also serves as a major contributor to their emergence *(Kohafkan* et al.*, 2012)*. In response to these pressing issues, the concept of sustainable agriculture has gained prominence since 1987, aligning with the broader notion of sustainable development (Tait et al., 2000). Various sustainable farming methods are being adopted, with organic farming emerging as a prominent approach to achieving the goals of sustainable agriculture.

Organic farming holds promise in addressing future agricultural challenges, ensuring food security, and safeguarding ecosystems

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https://doi.org/10.1016/j.heliyon.2024.e31792
Received 21 August 2023; Received in revised form 21 April 2024; Accepted 22 May 2024
Available online 23 May 2024
2405-8440/

while producing wholesome food that benefits all. In Vietnam, the demand for organic agricultural products has witnessed a notable uptick in recent years, driven by concerns for health, embracing healthy lifestyles, and heightened environmental consciousness [3]. Consumers are increasingly willing to pay premium prices for quality organic products in a bid to safeguard health and environmental well-being. Moreover, sustainable agriculture fosters resilience and secures livelihoods for farmers [4]. Identifying a livelihood framework encompassing natural, financial, social, human, and physical capital aids in comprehending and implementing existing resources for planning production activities. Adopting sustainable agricultural practices represents a strategic move to help farmers balance available capital and pursue sustainable livelihood objectives.

A deeper comprehension of farmers' behaviors and the factors influencing their decisions is paramount to mitigating diffuse pollution from agriculture through regulatory compliance; indeed, environmental performance often hinges on agricultural practices. Furthermore, it plays a crucial role in economic analyses of farmers' decision-making, leading to more effective agricultural and environmental policies. Understanding and promoting sustainable farming methods among farmers will foster a harmonious balance between economic development and environmental protection.

The novelty of this study compared to previous research is demonstrated in three key aspects. Firstly, while earlier studies *(*[5]*; Serebrennikov* et al.*, 2020)* have primarily focused on the behavior of farmers adopting sustainable agricultural methods in the EU or have only considered specific behavioral theories [6], our study uniquely centers on sustainable agricultural practices among Vietnamese farmers. Secondly, our research introduces the New Ecological Model (NEP) scale as a suitable variable, replacing personal norms, to acknowledge the significance of NEPs in representing social factors. Thirdly, building upon the theoretical framework of the sustainable livelihood framework developed by the UK Department for International Development (DFID), our study expands by incorporating additional non-behavioral factors influencing the decision-making of Vietnamese farmers. These factors encompass human capital, natural capital, financial capital, physical capital, and social capital. In terms of practical implications, our study represents the first comprehensive examination considering both behavioral and non-behavioral factors influencing Vietnamese farmers' decisions to adopt sustainable farming practices. Alongside refining and enhancing the theoretical framework, our research employs a dataset comprising 303 farming households across four provinces in Vietnam to validate the proposed research framework using two analytical models – Structural Equation Model (SEM) and Logit. As a result, the findings offer valuable insights to aid in the formulation of strategic policies to advance Sustainable Development Goals (SDGs), particularly policies promoting responsible production and consumption patterns (Goal 12), fostering social equity, reducing farmer vulnerability and poverty, and mitigating adverse environmental impacts stemming from intensive agricultural practices Furthermore, the research's innovative approaches and policy implications are intended to engage various stakeholders including researchers, government entities, non-governmental organizations, food organizations, and charities. Lastly, with its comprehensive theoretical framework, our study serves as a valuable reference for the application of sustainable farming methods amidst evolving socio-economic conditions and the prevailing climate challenges.

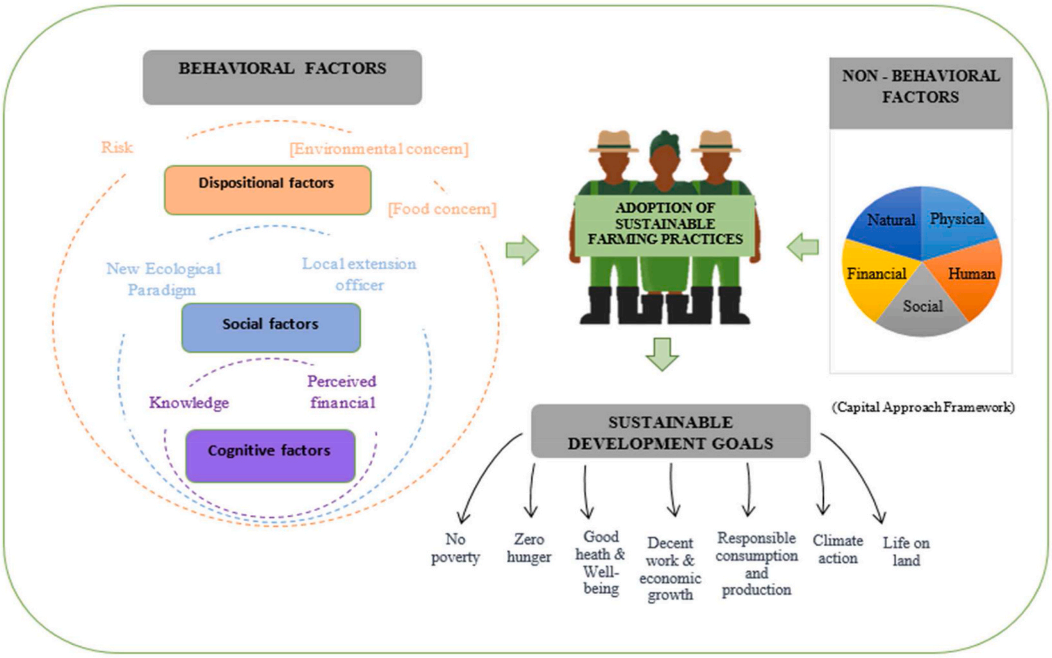

Fig. 1. Description of proposed theoretical framework.

2. Theoretical framework

Our research delineates three categories of behavioral factors influencing the decision-making processes of Vietnamese farmers regarding organic farming, namely dispositional, social, and cognitive factors [5]. Moreover, our study is anchored in the Theory of Sustainable Livelihoods Framework (SLA), which posits five sources of capital as the bedrock to assist farmers in ensuring livelihood security and poverty reduction. Given the SLA's comprehensive nature, encompassing various facets of farmers' livelihoods, it serves as an ideal theoretical framework for synthesizing non-behavioral factors impacting farmers' decisions to adopt sustainable farming practices. We classify these five types of capital as non-behavioral factors because they represent resources available for utilization in sustainable agricultural production, distinct from individual decisions or actions.

However, we do not include institutions and culture as non-behavioral factors influencing farmers' decisions to adopt sustainable farming practices. While institutions encompass laws, regulations, and procedures governing individuals' engagements in production or business, culture pertains to the values, beliefs, and customs of a society. Though these factors can exert significant influence on the utilization and management of other resources, they are not standalone capital classes and cannot replace non-behavioral factors. Additionally, our research not only assesses the impact of both behavioral and non-behavioral factors on Vietnamese farmers' decisions regarding sustainable agricultural practices but also endeavors to address seven goals within the Sustainable Development Goals framework. Therefore, this paper presents the theoretical framework (Fig. 1) and corresponding hypothesis.

Dispositional factors forecast a farmer's inclination toward certain behaviors [7]. These factors, often linked to an individual's traits, encompass personality, motivation, values, beliefs, interests, and shared objectives. Numerous studies have highlighted the significant impact of dispositional factors on farmers' adoption of environmentally friendly practices [8–10]. For instance, a farmer's personality and level of risk tolerance can influence their decision to adopt specific sustainable methods [11]. This study encompasses six types of risks: driving, investment, sports, health, social, and workplace risks. Among survey participants, environmental and food safety concerns emerged as the primary areas of apprehension.

H1. (+) The dispositional factors positively affect farmers' adoption of sustainable farming practices.

Social factors elucidate how societal norms, including perceptions of others, shape farmers' decision-making in farming practices. Dessart et al. [5] posit that interpersonal relationships play a pivotal role in farmers' adoption of environmentally sustainable practices. Numerous studies have underscored the significant correlation between social factors and farmers' embrace of sustainable farming techniques [12,13]. In our study, we view the New Ecological Paradigm (NEP) scale as a fitting variable to replace personal norms, given its relevance in capturing social factors. Several studies have explored the nexus between NEP and farmers' adoption of sustainable farming practices. For instance, *Klonsky* et al. *(2008)*[14] surveyed farmers in California to gauge their attitudes toward environmental issues and their uptake of sustainable agricultural practices. The findings revealed that farmers with higher NEP scores were more inclined to reduce pesticide usage and implement conservation tillage methods to mitigate adverse impacts on the environment.

H2. (+) Social factors as measured by the NEP scale positively affect farmers' adoption of sustainable farming practices.

Cognitive factors play a crucial role in farmers' decision-making regarding sustainable farming practices. Previous research has consistently shown a significant impact of perceived factors on farmers' adoption of environmentally friendly farming methods [12,15,16]. The knowledge of sustainable farming practices and farmers' perceptions of the financial benefits or risks associated with such approaches influence their likelihood of engaging in organic farming.

H3. (+) Cognitive factors positively affect farmers' adoption of sustainable farming practices.

In agricultural systems, indicators of human capital encompass household size, education levels, and attitudes toward the environment and climate change. *Angrist* et al. *(2019)* utilize an educational level as a proxy for human capital. Recent studies have also delved into enhancing agricultural sustainability through education and training, aiming to improve efficiency and effectiveness *(Raidimi E. N. & Kabiti H. M., 2019)*. Cuaresma [17] posits that human capital comprises educational level, years of experience, and training. Djomo & Sikod [18] suggest that training programs enhancing agricultural community skills and knowledge can bolster human capital, responding effectively to education and experience. Investment in human resources has the potential to enhance agricultural *productivity (Riddell, 2006)*. *Kassie (2009)*[19] argues that male farmers typically enjoy better access and control over resources, particularly in developing nations. Conversely, research indicates a significant negative relationship between the age of the household head and farmers' adaptation decisions *(*[20]*; Bayard* et al.*, 2007*[21]*)*. Our study addresses human capital by considering the age of survey respondents and the educational level of the household head.

H4. (+) Human capital positively affects farmers' adoption of sustainable farming practices.

Social capital encompasses trust, understanding, and cooperation among individuals and groups *(Goodwin, 2003)*. Essentially, it refers to networks and connections, including patrons, neighbors, kinship ties, characterized by relationships of trust, mutual assistance, formal and informal groups, shared knowledge, values, behaviors, common principles, customs, collective representation, mechanisms for participation in decision-making, and leadership. Social capital often manifests in the interactions between farm households and agricultural organizations [22]. Engaging in discussions with neighbors on topics related to organic farming can foster awareness of its benefits and address concerns about its effectiveness.

H5. (+) Social capital positively affects farmers' adoption of sustainable farming practices.

Physical capital constitutes a crucial asset representing the fundamental prerequisites for adopting farming methodologies [23]. This encompasses arable land, machinery, tools, and equipment, along with convenient access for farmers to their production areas and markets, facilitating faster and more efficient crop cultivation, saving time and labor. Farm size can significantly influence a farmer's decision to adopt organic farming. Larger farms often have greater economic viability for practicing sustainable agriculture, as they typically possess greater access to resources such as labor, equipment, and organic inputs.

H6. (+) Physical capital positively affects farmers' adoption of sustainable farming practices.

Financial capital serves as a crucial intrinsic asset for farmers, empowering them to reinvest in their farms to develop strategies for coping with climate change [23]. Farmers with higher incomes are often more inclined to adopt sustainable farming methods *(Devendra* et al.*, 2016;* [24]*),* as these methods frequently necessitate investments in technology and modern equipment. Additionally, organic farming typically entails higher production and labor costs compared to conventional farming, posing challenges for low-income farmers to embrace more sustainable practices.

H7. (+) Financial capital positively affects farmers' adoption of sustainable farming practices.

Natural capital comprises renewable and non-renewable natural resources that offer direct benefits, such as clean air, and indirect benefits, such as economic strengthening. In agricultural contexts, natural capital primarily encompasses climatic conditions (e.g., temperature, precipitation, humidity, solar radiation) and soil conditions (e.g., texture, structure, organic matter percentage, pH, and depth). Nearby green spaces like forests, grasslands, and wetlands provide essential ecosystem services. Farmers with better access to such green areas are more inclined to adopt sustainable farming methods, enhancing soil quality, increasing crop yields, and contributing to ecosystem preservation. Additionally, environmental factors such as air and water quality can significantly influence farmers' decision-making processes.

H8. (+) Natural capital positively affects farmers' adoption of sustainable farming practices.

Identifying both behavioral and non-behavioral factors influencing the decisions of Vietnamese farmers to adopt sustainable agriculture not only benefits the farmers themselves but also contributes to achieving Sustainable Development Goals (SDGs). Understanding farmer behavior facilitates the promotion of environmentally friendly farming practices, thereby contributing to ensuring food security and advancing the goal of zero hunger (SDG 2). Additionally, transitioning to organic agriculture reduces agricultural waste, promoting responsible consumption and production (SDG 12) and climate action (SDG 13). Moreover, sustainable agriculture plays a pivotal role in poverty alleviation (SDG 1) by restoring and securing farmers' livelihoods, fostering rural economic development, and creating opportunities for decent work and economic growth (SDG 8). Lastly, our research aligns with SDG 15 (Life on Land) as it underscores the significance of conserving biodiversity and soil health in sustainable agriculture.

3. Data and methodology

3.1. Econometric model

In empirical analyses of behavior change measures, models such as Logit or the Generalized Structural Equation Model (GSEM) are widely employed. *Scholars like Kostas (2018)*[25] *and To-The & Nguyen-Anh (2019)*[26] have applied both binary Logit and GSEM to explore behavioral factors influenced by external factors. The utilization of Generalized Structural Equation Modeling and Logit models aids in identifying suitable indicators for test models, overcoming the limitations of less appropriate models through multivariate data analysis methods. These models offer greater flexibility and depth in analysis, resulting in more efficient estimation coefficients compared to Probit or Logit models. This indicates that both behavioral and non-behavioral factors are interconnected and impact the dependent variable, which is the decision to adopt sustainable agriculture.

The logistic regression model that defines the application of organic farming by farmers is formulated as follows:

$$\text{Logit Y} = \left[\frac{Y_i}{1 - Y_i}\right] \tag{1}$$

$$\text{Ln } \frac{Y}{1 - Y} = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_{16} X_{16i} + \varepsilon_i \tag{2}$$

Where i mean the i^{th} observation in the sample, Y is the probability of the result, ε_i is the random error, β_0 is the intercept term, and β_1, β_2, … β_k are the coefficients related with each independent variable X_1, X_2, … X_{16}.

According to Neupane et al. [27] it should be noted that the estimated coefficients do not directly indicate the effect of the change in the respective explanatory variables on the probability (Y) of the outcome occurring. Instead, the coefficients reflect the effect of each explanatory variable on the log of odds $\{\ln [\frac{Y_i}{1-Y_i}]\}$.

The variables in the model are to risk tolerance (X_1), Concerns (X_2), Social factors (X_3), Knowledge (X_4), Perceived financial (X_5), Age of the interviewees (X_6), Square of the age of the interviewees (X_7), Education level of household head (X_8), Experience from commune local extension (X_9), Information exchange among farmers (X_{10}), Joining organizations (X_{11}), The linkage between farmers and local government systems (X_{12}), Farm size (X_{13}), Household monthly income (X_{14}), Green coverage of the surrounding environment (X_{15}), Quality of the environment (X_{16}).

3.2. Sampling technique and data collection

The data used in this study was collected by the author through field surveys in villages and farmer households in 4 provinces of Vietnam (Ha-Noi, Nghe-An, Lao-Cai, Bac-Giang) (Fig. 2). All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of VNU University of Economics and Business (Project identification code KT 02.17).

The sampling and questionnaire design comprised three phases: Firstly, surveyors consulted local and government officials experienced in Organic Agriculture to identify suitable production and farming areas. Subsequently, the study area was delineated, spanning eight districts across four provinces, based on consultations with local government officials who provided lists of farmers engaged in organic cultivation within each research area. In the final phase, households were randomly selected from these lists for interviews. Additionally, focus group discussions and pilot surveys were conducted with older individuals and community leaders to gauge questionnaire comprehension and response clarity. The questionnaire aimed to collect demographic information about the farmers, categorizing socio-demographic data into five types of non-behavioral factors: human capital, financial capital, social capital, physical capital, and natural capital. Questions were also posed regarding participants' attitudes toward risk and their level of risk tolerance, along with a household survey incorporating New Ecological Paradigm (NEP) propositions.

The survey was conducted from June to August 2022. Respondents were randomly selected from lists provided by local government officials across the designated regions to mitigate potential biases in subsequent empirical analyses. A total of 303 responses were obtained from households spanning four provinces and eight districts (Table 1).

4. Result

4.1. Descriptive analysis

The descriptive statistics of the explanatory variables, along with the sources of the variables, are presented in Table 2 (and Table 7 in the Appendix). Regarding propensity factors, the mean values of risk variables range from 1386 to 3,106, indicating a tendency among individuals to avoid risks in transportation, investment, recreational sports, activities, and health and social relationships. Particularly noteworthy are the mean values for attitudes towards environmental protection and food safety, which are 1452 and 1,386, respectively, reflecting a significant interest among people in these areas. In terms of social factors, respondents tend to endorse beliefs in ecological activities and their benefits to the environment, recognizing the threat that human activities pose to the natural balance. However, there's also some hesitation in fully accepting the limitations of human development, with individuals still deliberating whether human intervention in nature could lead to adverse consequences. Regarding cognitive factors, the survey results indicate that 75.74 % of respondents are aware of organic agriculture, and 86.96 % of individuals or households have attended a training conference on organic farming at some point. Remarkably, 91.91 % of individuals or households have engaged in organic farming activities. Additionally, variables related to financial perception suggest an increasing awareness among people regarding price changes due to inflation and the economic benefits for themselves and their families.

Concerning human capital, the survey reveals that the age range of farm owners extends from 18 to 74 years old, with an average

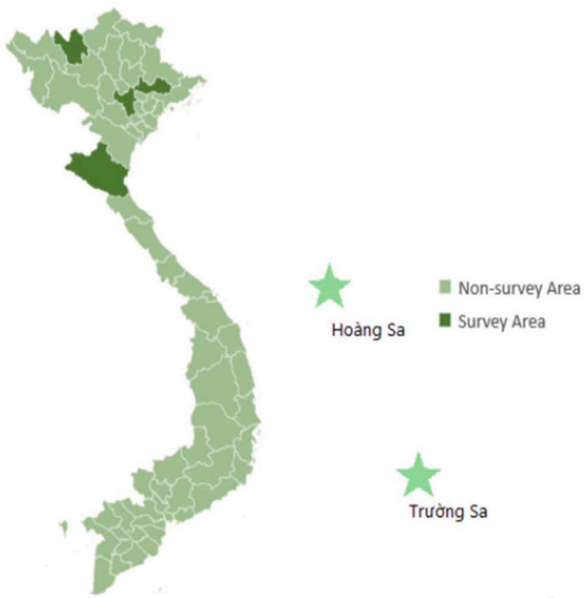

Fig. 2. Map of the surveyed areas.

Table 1
Sample distribution in the study location.

Provinces	Districts	Observations
1. Lao-Cai	1. Bac Ha	55
	2. Bao Thang	51
2. Ha-Noi	3. Hoai Duc	10
	4. Phuc Tho	11
	5. Thuong Tin	13
	6. Thanh Tri	11
3. Bac-Giang	7. Lang Giang	100
4. Nghe-An	8. Quynh Luu	52
		Totals: 303

age of 49. This indicates that older individuals, with their extensive experience in agricultural cultivation, constitute a significant portion of the surveyed population. In Vietnam, educational attainment is typically measured from 5 years of age, when children begin elementary school, until the age of 24, upon completion of college education.

Regarding social capital, the average value of the Communication variable is 2.1617, indicating that survey respondents seldom engage in discussions with their neighbors about agriculture-related topics. Additionally, 35.31 % of farmers are involved in agricultural cooperative organizations and local or national farmers' associations. Notably, the findings reveal that as many as 74.25 % of surveyed individuals have connections to political and social organizations or have ties to the local government through family members, relatives, or friends. These connections are beneficial as they provide support and timely updates on information and policies in the economic and agricultural sectors.

Table 2
Correlation Matrix from the Multivariate Logit Model.

Risk							
Driving	1.000						
Investment	0.376*	1.000					
Sport	0.403*	0.388*	1.000				
Working	0.318*	0.471*	0.490*	1.000			
Health	0.457*	0.372*	0.527*	0.552*	1.000		
Social	0.367*	0.409*	0.443*	0.493*	0.546*	1.000	
Concern							
EnvironmentalConcern	1.000						
FoodConcern	0.651*	1.000					
Social	1.000						
Population							
Nature_Modify	0.193	1.000					
Nature_Cons	0.314*	−0.036	1.000				
Ingenuity	0.047	0.170	0.087	1.000			
Abusing	0.255*	0.094	0.452*	0.233*	1.000		
Learning	0.211*	0.213*	0.191	0.419*	0.241*	1.000	
AnimalPlant	0.205*	0.154	0.228*	0.358*	0.357*	0.468*	1.000
BalanceNat	0.111	0.181	−0.025	0.058	−0.022	0.062	0.102
LawOfNature	0.196	0.138	0.186	0.307*	0.326*	0.458*	0.448*
EcologyCrisis	0.095	0.047	0.114	0.028	0.177	0.114	0.054
LimResources	0.185	0.079	0.182	0.280*	0.377*	0.293*	0.394*
RuleNature	0.196	0.191	0.051	0.197	0.080	0.225*	0.130
NatDelicated	0.135	0.121	0.193	0.161	0.229*	0.171	0.220*
ControlNat	0.086	0.178	0.139	0.270*	0.143	0.291*	0.233*
NatCatastrophe	0.134	0.130	0.203*	0.238*	0.330*	0.246*	0.351*
BalanceNat	1.000						
LawOfNature	0.117	1.000					
EcologyCrisis	0.153	0.110	1.000				
LimResources	0.064	0.380*	0.117	1.000			
RuleNature	0.228*	0.131	0.220*	0.228*	1.000		
NatDelicated	0.028	0.224*	0.090	0.265*	0.135	1.000	
ControlNat	0.205*	0.229*	0.112	0.194	0.368*	0.247*	1.000
NatCatastrophe	−0.038	0.292*	0.009	0.387*	0.143	0.439*	0.296*
NatCatastrophe	1.000						
Knowledge							
InfoOrganic	1.000						
PastOrganic	0.309*		1.000				
TrainingAttended	0.431*		0.290*		1.000		
Perceived financial							
change_cost	1.000						
change_benefit	0.435		1.000				

Note: *, **, and *** denote statistical significance at 10 %, 5 %, and 1 % level, respectively.

Regarding physical capital, the average landholding per household is 4696.3 square meters, which is considered a significant factor influencing participation in agricultural activities.

In terms of financial capital, individuals' monthly incomes range from 6.21 million VND to 10.75 million VND, indicating that many individuals or households possess the financial means to invest in agricultural pursuits. Lastly, concerning natural capital, green spaces and environmental quality are evaluated at a reasonable level, as the surveyed areas are predominantly rural and not yet impacted by urbanization or industrialization.

4.2. Analysis of factors affecting the adoption of sustainable farming practices

4.2.1. Model specification tests

Before estimating the GSEM and Logit models, we conducted tests to assess the correlation between variables and utilized principal components analysis (PCA) to identify the key components contributing to the majority of variance in the data. Due to the numerous dimensions covered in the article, processing and comprehending multidimensional data efficiently can be challenging. Therefore, to streamline the analysis, it is essential to reduce the dimensionality of the data by identifying proxies capable of accurately capturing the variability present in groups of related variables. This objective can be accomplished through the aforementioned methods.

We began testing the correlation between variables, Table 2 shows the following results. New representative variables are combined from variables with correlation coefficients: Risk, Concern, Social, Knowledge, and Perceived financial. From the correlation table, we can see that the components that make up the new variables include: The Risk variable represents the variables: Driving, Investment, Sport, Working, Heath, and Social. The variable Concern represents Environmental Concern and Food Concern. The Social variable represents the following variables: NatCons, Abusing, Learning, AnimalPlant, LawOfNature, LimResources, NatDelicated, and NatCatastrophe (The rest of the NEP variables are not obtained because they have uncorrelated coefficients). The Knowledge variable represents the InfoOrganic, PastOrganic, and Training Attended variables. The Perceived financial variable represents the variables: change_cost and change_benefit.

Next, the group use PCA to reduce the data dimension of the representative variables. In Table 3, the summary statistics table of the main representative variables is the PCA results.

4.2.2. Econometric model result

In Table 5 (in the Appendix), the results of the GSEM model are presented. Farmers' decisions regarding the adoption of sustainable agriculture are influenced by two primary groups: behavioral and non-behavioral factors. The behavioral factors encompass dispositional, social, and cognitive aspects, while the non-behavioral factors include human capital, social capital, physical capital, financial capital, and natural capital. As noted by Nguyen-Anh et al. [28], the Akaike information criterion (AIC) and Bayes information criterion (BIC) are utilized to explore the application of information criteria as alternatives to step-by-step methods in the variable selection process. In Table 6 (in the Appendix), the full model emerges as the best-fitted model, with all employed variables being validated.

Within the behavioral factors group, a positive correlation coefficient of 0.264 is observed between willingness to risk tolerance (in areas such as investment, health, and work) and the adoption of sustainable agricultural practices. The results from the logit-generalized linear equation model corroborate our initial hypothesis, indicating that farmers with higher risk tolerance are more likely to adopt sustainable farming practices, particularly organic farming. This finding aligns with a study by Ortega et al. [29], which demonstrated that farmers with greater risk tolerance might be more open to accepting lower crop yields or the risk of crop failure. Conversely, survey respondents who exhibit risk aversion are hesitant to adopt sustainable practices, often favoring the relative stability of conventional farming methods to safeguard their crop yield and income source. This observation is consistent with the findings of *Zhen Liu* et al. *(2018)* [30], suggesting that risk-averse farmers are inclined to choose pesticides over alternative pest control methods, even if the latter is more cost-effective and environmentally friendly.

Furthermore, the data indicate that awareness of food safety and environmental protection issues positively influences farmers' engagement in sustainable agricultural practices, with an estimated correlation coefficient of 0.223. This suggests that farmers who prioritize environmental protection and food safety are more inclined to practice organic farming. Through organic farming, farmers can mitigate the negative impacts of agricultural production on the environment, enhance soil quality, conserve water, and preserve biodiversity. Moreover, farmers who prioritize food safety are more likely to adhere to guidelines and regulations pertaining to food production, as demonstrated in the study by *Spanoghe (2013)* [31], wherein farmers who complied with food safety standards used fewer pesticides. The adoption of sustainable farming methods not only brings economic benefits to households but also contributes to environmental sustainability, thereby reducing health risks for both farmers and consumers.

Table 3
Summary statistics between representative variables.

Variable	Obs	Mean	Std. dev	Min	Max
Risk	303	1.53e-10	1.794	−2.087	7.365
Concern	303	−4.22e-08	1.285	−1.162	3.005
Social	303	9.28e-10	1.780	−8.484	3.634
Knowledge	303	2.09e-08	1.300	−2.818	1.172
Perceived financial	301	−9.31e-09	1.140	−423	7.924

The utilization of the NEP model scale to represent social factors exhibits a positive correlation with organic farming, with a coefficient of 0.225, affirming the second hypothesis that social factors positively influence farmers' adoption of sustainable farming methods. Farmers with higher NEP scores tend to possess greater awareness of environmental issues and the ecological impact of agriculture. They are more inclined to embrace sustainable practices to mitigate adverse environmental effects. In our study, eight propositions in the NEP are deemed significant for farmers' decisions to adopt organic farming. These propositions include beliefs such as the delicate balance of nature, the abuse of the environment by humans, and the potential for ecological catastrophes if current trends persist. The positive relationship between NEP and the adoption of organic farming practices by surveyed farmers underscores that individuals who align with NEP statements are more likely to engage in sustainable agriculture. This is attributed to their heightened awareness of environmental issues and agriculture's ecological impacts, as well as their propensity to value environmental conservation. Sustainable practices contribute to mitigating negative environmental impacts. However, this finding contrasts with the results of the study by Pham et al. [32].

Conversely, the experience gained from local extension officers exhibits a negative correlation with organic farming, with a coefficient of −1.395. One possible explanation for this negative correlation could be that local extension workers require more knowledge or experience in organic farming practices. It might be attributed to motivational pressures in farming practices from higher officials or other stakeholders. Consequently, farmers may lack trust in the information they receive, or they may not receive adequate exposure to organic farming methods from commune extension services. This finding contrasts with a study by *Nguyen* et al. *(2018)*, which examined the impact of an extension program on the adoption of sustainable agricultural practices by coffee farmers in the Central Highlands of Vietnam. The research demonstrated that extension programs promote sustainable practices such as shade coffee and organic farming.

Cognitive factors are evaluated based on farmers' knowledge and experience in sustainable agriculture and their perception of the economic benefits associated with practicing organic farming. The positive relationship between cognitive factors and organic farming practices indicates that cognitive factors positively influence farmers' adoption of sustainable farming practices, with an estimated correlation coefficient of 1.449. Farmers who are introduced to and educated about organic agriculture, particularly those with experience in organic farming practices or who have participated in training classes on organic agriculture, are inclined towards adopting sustainable agricultural practices. This aligns with the findings of Villamil et al. [33], which showed that past experiences, such as exposure to organic farming methods or participation in environmental initiatives, significantly predict farmers' decision to practice organic farming. Farmers who underwent training and acquired knowledge of production techniques were highly likely to transition from conventional production to organic farming, particularly orange and pomelo growers in Tuyen Quang *(Nguyen* et al.*, 2021)*.

On the contrary, perceived financial factors exhibit a negative correlation with farmers' decision to engage in sustainable agriculture, with a coefficient of −1.315. This negative correlation may stem from Vietnamese farmers' perceptions of the financial benefits or costs associated with adopting organic farming. Organic farming entails a more stringent agricultural input process, prohibits the use of pesticides, and necessitates investment in advanced technological equipment. Consequently, organic products often command higher prices than conventional agricultural products, leading to potentially higher profits. However, for small-scale farmers, this can pose a challenge due to the increased risk of crop failure and fluctuating costs associated with organic farming, making it difficult for them to afford the investment. Hence, farmers' perception of economic benefits, tied to increased farm profits or income, negatively influences their inclination to embrace organic farming *(Läpple* et al.*, 2011)*[34].

In terms of human capital, the variable representing age demonstrates a positive correlation value of 0.344. Notably, through the results obtained from calculating the turning point using regression coefficients, it was discovered that although the average age of farmers in the surveyed areas is 49, older individuals still tend to engage in sustainable agriculture. This finding suggests that middle-aged farmers are more predisposed to practicing sustainable agriculture, likely due to their accumulated experience and understanding of agricultural practices, including organic farming methods. Additionally, middle-aged farmers are better equipped to respond to adverse environmental changes and are more willing to adopt measures to mitigate them. In a study on the impact of mobile phone and internet technology on the income of farmers in Pakistan, *Nawab* Khan et al. [35] found that it is difficult for most growers over 50 to attain stable non-agricultural income. This may also be a reason for farmers choosing to do agriculture, especially sustainable agriculture. Organic farming is often considered a sustainable and environmentally friendly approach, and older farmers may generate income or prioritize land conservation and resources for future generations. However, upon adding squared terms, the turning point is easily calculated at 60 years old, beyond which farmers are less inclined to pursue organic agriculture. This aligns with research by *Chatzi Michael (2014)* and *Arunrat* et al. *(2017)* [36], which also yielded similar results. After reaching the age of 60, farmers are less inclined to participate in sustainable agriculture due to the significant capital and effort required. At this stage, farmers may lack the requisite health and time, and may prioritize savings for other purposes instead of investing in a new farming method.

Moreover, the variable representing education (Edu) demonstrates a positive correlation value of 0.551, indicating that individuals with higher levels of education are more likely to adopt sustainable agricultural practices. This can be attributed to the enhanced understanding and awareness of the benefits of sustainable agriculture among more educated individuals, coupled with their knowledge of agricultural activities and the economy. Research by *Kloppenburg* et al. *(1991)* [37] concludes that farmers with higher education levels are better equipped to manage the risks and benefits associated with new ideas. Experienced farmers are more likely to recognize the value of investments, while highly educated farmers are expected to embrace new technologies and farming methods based on their perceptions of the potential benefits of sustainable agricultural practices.

In terms of social capital, the estimated coefficient for the variable "Communication," representing the exchange of agricultural information among farmers, is −0.305. This negative coefficient indicates an inverse relationship between information exchange about agriculture among farmers and the likelihood of engaging in sustainable agriculture. This negative correlation can be attributed to the necessity for increased communication among farmers to facilitate diverse viewpoints, understandings, and expectations regarding organic farming practices. For instance, farmers advocating for conventional farming methods to ensure productivity and profitability may be less inclined to share knowledge and experiences about sustainable agricultural practices. This finding contrasts with the research conducted by Pham et al. [32], which suggests that sharing information with colleagues such as neighbors and friends plays a crucial role in promoting practices like crop rotation and the use of organic fertilizers.

Contrary to the initial hypothesis, participation in local and national farmers' associations negatively impacts the likelihood of adopting sustainable agricultural practices, with an estimated correlation coefficient of −1.489. This negative correlation suggests that surveyed farmers lack trust in the officers responsible for managing agricultural extension services within cooperative organizations. Hence, there is a need to enhance the relationship between extension trainers and trainees. One potential solution could involve providing additional training for cooperative extension officers at the district or provincial level to bolster trust between the two parties. Supporting this notion, a study by Pham et al. [32] indicated that local farmers participating in the survey expressed reservations about extension workers, citing their lack of agricultural experience due to their youth.

However, the stronger the linkage between farmers and local government systems, the more significant the impact on the adoption of sustainable agricultural practices, as evidenced by a positive correlation coefficient of 0.680. This suggests that closer ties with the local government system enable farmers to access information about government policies or support measures earlier. While participation in political organizations was not a significant factor in the study conducted by *Nguyen-Duc* et al. *(2021)* on the conversion to organic agriculture in Tuyen Quang province, Vietnam, the emergence of numerous private agricultural cooperatives reflects a common goal among members to access larger loans from agricultural banks, share farming techniques, and collaborate on production and marketing efforts. Political connections can also be viewed as a form of social capital. Indeed, research by Markussen and Tarp [38] illustrates that farm households in Vietnam establish connections with state officials in various ways, such as having family members who are civil servants or relatives working in the local government. Farmers with such connections can gain early access to information about potential benefits and support programs for adopting sustainable farming methods, making them more likely to engage in sustainable agriculture [32].

In the section on physical capital, the estimated coefficient for farm size is −0.063, indicating a negative association with the adoption of sustainable agriculture. Larger farm sizes are less likely to engage in sustainable agricultural practices. This can be attributed to the labor-intensive nature of organic farming methods, their technical complexity, and the need for meticulous attention to detail, which may pose challenges in managing large-scale farms. In contrast, smallholder farmers with limited arable land may have an advantage due to the manageable size of their operations. This finding contrasts with studies by Gachango et al. [39] and Carmona et al. [40], which identified land area as a positive predictor of farmers' decisions. On larger farms, sustainable practices can potentially reduce pesticide and synthetic fertilizer costs, enhance soil quality, and yield long-term benefits.

Regarding financial capital, total household income emerges as a key driver for farmers to embrace sustainable agricultural practices, with a positive correlation coefficient of 0.354. Higher-income farmers are more inclined to adopt and sustain sustainable agricultural methods. This correlation is understandable as household finances enable reinvestment in farms [23]. High-income farmers can afford initial investments in modern technology and equipment, which yield long-term benefits. Additionally, organic farming often entails higher labor and production costs compared to conventional methods. Higher income levels facilitate easier access to loans from agricultural banks, thereby diversifying financial resources available for initiating and maintaining sustainable agricultural activities.

Contrary to the hypothesis, the presence of nearby green spaces exhibits a negative correlation with the adoption of sustainable agricultural practices, with a coefficient of −0.525. This negative correlation suggests that farmers residing and farming in untouched areas, such as the Northern mountainous region, are less likely to engage in organic farming practices. Conversely, farmers in lowland areas are more inclined towards sustainable agriculture due to the comparative advantages and developmental incentives offered. This negative correlation could be attributed to natural habitats like forests or wetlands, which may increase the risk of pests and diseases or limit farmers' access to land and resources in surrounding green areas. Additionally, competition for land and natural resources for purposes like ecotourism or conservation may pose barriers to farmers in adopting sustainable farming methods, as evidenced by similar findings in the study by *Jules* Pretty [41].

In contrast, the hypothesis concerning natural capital suggests a positive impact of environmental quality on farmers' adoption of sustainable agricultural practices, with an estimated coefficient of 0.251. Regions boasting favorable farming conditions and superior environmental quality, with minimal exposure to natural disasters and climate change phenomena, are more conducive to motivating farmers to participate in sustainable agricultural activities. This aligns with research by Barreto et al. , which indicates that farmers in the Brazilian Amazon are more likely to adopt sustainable farming methods in areas characterized by high environmental quality. Environmental quality, as measured by intact forest cover, soil fertility, and water quality, plays a critical role in determining agricultural sustainability. Poor air quality can hinder crop yields and restrict certain farming practices, while water pollution can limit access to clean water sources for irrigation and agricultural production, as highlighted in studies by *Zhan* Wang et al. [42].

5. Conclusion

Agriculture stands as one of the primary contributors to Vietnam's national income, representing a significant portion of the country's gross domestic product (GDP). While the agricultural sector has exhibited commendable performance, it has also been implicated in environmental degradation and the depletion of natural resources. Extensive use of chemical fertilizers and pesticides has resulted in soil degradation, water pollution, and other environmental concerns. Furthermore, the expansion of agricultural land has led to deforestation and biodiversity loss, particularly in the highland regions.

These environmental challenges pose significant threats to the long-term sustainability of Vietnam's agricultural sector, as well as the welfare of rural communities and the broader ecosystem. Addressing these issues necessitates collaborative efforts among the Vietnamese Government, stakeholders, and farmers to promote sustainable farming practices, including organic farming and agro-ecology, while enhancing the management of vital natural resources such as water, land, and forests. Our findings indicate that farmers exhibiting risk tolerance and concerns regarding food safety and ecological matters are more inclined to adopt organic farming practices. Additionally, our study identifies eight propositions from the New Ecological Paradigm (NEP) that influence farmers' decisions to engage in organic farming. Thus, there is a critical need for educational campaigns aimed at enhancing farmers' awareness, knowledge, skills, attitudes, and beliefs concerning environmental issues. Furthermore, organizing training sessions to disseminate the benefits of organic farming, guide farming techniques, irrigation, and crop care procedures, is essential to popularizing sustainable agricultural methods among farmers. Agricultural extension officers affiliated with organizations such as cooperatives and farmers' associations should receive comprehensive training to deepen their knowledge and foster trust among farmers. Moreover, concerted efforts by the Government and stakeholders are imperative to promote widespread adoption of sustainable farming methods and the consumption of organic agricultural products. Ensuring reasonable and stable costs associated with organic farming is vital to enable farmers to make informed, long-term decisions. Additionally, the Government should implement preferential lending policies, microcredit programs, or subsidy schemes to support farmers willing to embrace sustainable agriculture.

However, our study is not without limitations. We solely conducted empirical research utilizing survey data from four provinces in Vietnam. To address these limitations, future research should consider replicating the study across Vietnam to assess changes and variations over time. Additionally, expanding the dataset beyond Vietnam to include multiple regions or countries with diverse agricultural practices would enhance the reliability and representativeness of the study. Such endeavors would provide a broader perspective and facilitate the generalizability of our framework in varied contexts, thereby improving our understanding of its applicability. Diversifying data sources and conducting comparative analyses are crucial steps toward ensuring the robustness and generalizability of our findings.

CRediT authorship contribution statement

Nguyen Nguyen-Thi-Kim: Writing – review & editing, Supervision, Investigation, Conceptualization, Software. **Nguyen To-The:** Writing – original draft, Investigation, Data curation, Conceptualization. **Tuan Nguyen-Anh:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Phong Nguyen-The:** Writing – review & editing, Writing – original draft, Software, Resources, Methodology. **Thao Nguyen-Phuong:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Conceptualization. **Hieu Lai-Minh:** Writing – original draft, Software, Resources, Methodology, Investigation, Formal analysis, Data curation. **Thu Pham-Anh:** Writing – review & editing, Writing – original draft, Resources, Methodology, Formal analysis, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

Table 2
Summary of explanatory variables

Variable	Obs	Mean	Std. dev.	Min	Max
Dispositional Factors					
Driving	303	1.438	2.013	0	10
Investment	303	2.409	2.631	0	10
Sport	303	2.138	2.570	0	10
Working	303	3.105	3.137	0	10
Health	303	2.343	2.884	0	10
Social	303	2.075	2.447	0	10
Environmental_Concern	303	1.452	0.511	1	3
Food_Concern	303	1.386	0.507	1	3
Social Factors					
NatCons	303	2.996	1.246	1	5
Abusing	303	3.422	1.247	1	5
Learning	303	4.026	0.775	1	5
AnimalPlant	303	3.973	0.849	1	5
LawOfNature	303	4.016	0.827	1	5
LimResources	303	3.858	0.859	1	5
NatDelicated	303	3.646	0.940	1	5

(*continued on next page*)

Table 2 (*continued*)

Variable	Obs	Mean	Std. dev.	Min	Max
NatCatastrophe	303	3.877	0.953	1	5
Cognitive Factors					
InfoOrganic	303	1.514	0.500	1	2
PastOrganic	303	1.838	0.368	1	2
TrainingAttended	303	1.739	0.439	1	2
PastChangeInCost	303	0.175	0.609	1	3
ChangeInBenefit	303	0.142	0.442	1	3
Human Capitals					
Age	303	49.049	12.730	18	74
Age^2	303	2567.386	1219.951	324	5476
Educ	303	6.339	1.736	0	12
Social Capitals					
Communication	303	2.161	1.238	1	5
Cooperative	303	0.353	0.478	0	1
Association	303	0.742	0.437	0	1
Physical Capitals					
FarmSize	303	4696.3	7312.181	0	70000
Financial Capitals					
Lnincome	303	8.472	0.695	6.214	10.751
Natural Capitals					
GreenNearby	303	7.524	2.106	0	10
EnvQuality	303	6.422	2.168	0	10

Table 5
Model estimation results.

Variable	Coefficient	Robust.Std.Err.	P-value
Organic			
Risk	0.264	0.175	0.131
Concern	0.223*	0.129	0.085
Social	0.255***	0.049	0.000
Knowledge	1.449***	0.193	0.000
Perceived_financial	−1.315***	0.163	0.000
Age	0.344***	0.055	0.000
Age^2	−0.002***	0.001	0.000
Educ	0.551	0.629	0.381
Local_extension_officer	−1.395**	0.700	0.046
Communication	−0.305	0.253	0.229
Cooperative	−1.489*	0.897	0.097
Association	0.680	0.665	0.306
Farmsize	−0.063***	0.021	0.002
lnIncome	0.354	0.284	0.213
GreenNearby	−0.525***	0.051	0.000
EnvQuality	0.251*	0.141	0.077
Constant	−4.210	2.962	0.155

Note: *, **, and *** denote statistical significance at 10 %, 5 %, and 1 % level, respectively.

Table 7
Definition of explanatory variables

Key variables	Sub-key variables	Definition	Sign/Variable Type	Source
Dispositional	Risk	Risks of driving	(+)	Viscusi et al., 2011
Factors	Concern	Risks when investing	Discrete	Li & Zhou, 2010
Social Factors	Social	Risks of sports activities	(+)	Taylor, 2017
Cognitive	Knowledge	Health risks	Discrete	Best, 2008
Factors	Perceived	Social risks	(+)	Jain & Ranjan,
Human	Financial	Risks at work (Scale from 0: avoid to 10: willing)	Discrete (+)	2017
Capitals	Age	Environmental concerns	Discrete	Kean et al., 2016
Social	Age2	Safety concerns food (Scale from 1: least)	(+)	Dunlap, 2000
Capitals	Educ	Upgraded version of Personal (Scale from 1: least)	Dummy	Ritaban &
Physical	Communication	Experience from commune agricultural extension (Scale from 1: least)	(−)	Morshed. 2014
Capitals	Cooperative	Information about organic farming	Discrete	Andrew et al., 1997
Financial	Association	Having worked in organic farming in the past Participation in training	(+)	Nga et al., 2021
Capitals	Farmsize	courses on organic farming (0: Do not know, 1: Know)	Continous (+)	John & Sandy,
Natural	Lnincome	Change of the value in the past Change in benefit (1: No change, 2: Change	Continous (+)	1994
Capitals	GreenNearby	little, 3: Change much)	Continous	Gerard et al.,. 2016
	EnvQuality	Age of the interviewee (years)	(+)	Hamid et al., 2018
		Square of the age of the interviewee	Dummy (+)	Dick et al., 2014

(*continued on next page*)

Table 7 (*continued*)

Key variables	Sub-key variables	Definition	Sign/Variable Type	Source
		Education level of household head (years)	Dummy	Valentinov, 2007
		Information exchange among farmers (1: least, 5: Frequent)	(+)	Fergus Lyon, 2000
		Joining agricultural cooperative organizations, local and national farmers' associations (1: Yes, 2: No)	Dummy (+)	Chen & Liu, 2019 M.J. 2020
		The linkage between farmers and local government systems (1: Yes, 2: No)	Continous	Tatlıdil & Boz, 2009
		Farm size (ha)	(+)	
		Household monthly income (mil.VND)	Continous	Ian Bowler, 2002
		Green coverage of the surrounding environment	(+)	Jules Pretty, 2007
		Quality of the environment (Scale from 0: least)	Discrete (+) Discrete	

Table 6
Log-likelihood, AIC and BIC of the models

Model	ll(model)	AIC	BIC
Full	−51.327	106.655	113.753
without Risk	−52.439	108.878	115.977
without Concern	−52.123	108.247	115.345
without Social	−52.115	108.231	115.328
without Knowledge	−52.827	109.655	116.753
without Perceived_finance	−73.172	150.345	157.443
without Human capital	−56.138	116.276	123.374
without Social capital	−53.955	111.911	119.008
without Physical capital	−55.146	114.293	121.391
without Financial capital	−52.115	108.231	115.337
without Natural capital	−75.141	154.283	161.704

References

[1] B. Hansen, H.F. Alrøe, E.S. Kristensen, Approaches to assess the environmental impact of organic farming with particular regard to Denmark, Agric. Ecosyst. Environ. 83 (1–2) (2001) 11–26.
[2] B.S. Reddy, Organic farming: status, issues, and prospects - a review, Agric. Econ. Res. Rev. 23 (2) (2010) 343–358.
[3] M.H. Thanh, S. Shamim, H.P.D. Kim, Rural-urban differences in willingness to pay for organic vegetables: evidence from Vietnam, Appetite 141 (1 October 2019) (2019) 104273.
[4] J. Park, R.A.F. Seaton, Integrative research and sustainable agriculture, Agric. Syst. 50 (1996) 81–100.
[5] F.J. Dessart, J. Barreiro-Hurlé, R. van Bavel, Behavioral factors affecting the adoption of sustainable farming practices: a policy-oriented review, Eur. Rev. Agric. Econ. 46 (2019) 417–471.
[6] J. Sok, J.R. Borges, P. Schmidt, I. Ajzen, Farmer behavior as reasoned action: a critical review of research with the theory of planned behavior, J. Agric. Econ. 72 (2021) 388–412.
[7] B.F. Malle, Attribution theories: how people make sense of behavior, in: Theories in Social Psychology, Wiley-Blackwell, Hoboken, NJ, USA, 2011, pp. 72–95.
[8] F.K. Yeboah, F. Lupi, M.D. Kaplowitz, Agricultural landowners' willingness to participate in a filter strip program for watershed protection, Land Use Pol. 49 (2015) 75–85.
[9] D. Hermann, O. Mußhoff, K. Agethen, Investment behavior and status quo bias of conventional and organic hog farmers: an experimental approach, Renew. Journal of Agriculture, Food System and Community Development 31 (2016) 318–329.
[10] K. Floress, S.G. de Jalón, S.P. Church, N. Babin, J.D. Ulrich-Schad, L.S. Prokopy, Toward a theory of farmer conservation attitudes: dual interests and willingness to take action to protect water quality, J. Environ. Psychol. 53 (2017) 73–80.
[11] J. Sok, H. Hogeveen, A.R.W. Elbers, O. Lansink, Perceived risk and personality traits explaining heterogeneity in Dutch dairy farmers' beliefs about vaccination against Bluetongue, Jounal of Risk Research 21 (5) (2018) 562–578.
[12] W.F.A. Dijk, A.M. Lokhorst, F. Berendse, G.R. de Snoo, Factors underlying farmers' intentions to perform unsubsidized agri-environmental measures, Land Use Pol. 59 (2016) 207–216, 2016.
[13] L. Kuhfuss, R. Préget, S. Thoyer, N. Hanley, P. le Coent, M. Nudges Désolé, Social norms, and permanence in agrienvironmental schemes, Land Econ. 92 (2016) 641–655.
[14] E.David Klonsky, What is Emptiness? Clarifying the 7th criterion for borderline personality disorder, J. Pers. Disord. 22 (No.4) (2008).
[15] A.J. Villanueva, M. Rodríguez-Entrena, M. Arriaza, J.A. Gómez-Limón, Heterogeneity of farmers' preferences towards agri-environmental schemes across different agricultural subsystems, J. Environ. Plann. Manag. 60 (2017) 684, 70.
[16] E.S. Pavlis, T.S. Terkenli, S.B.P. Kristensen, A.G. Busck, G.L. Cosor, Patterns of agri-environmental scheme participation in Europe: indicative trends from selected case studies, Land Use Pol. 57 (2016) 800–812.
[17] J.C. Cuaresma, Income projections for climate change research: a framework based on human capital dynamics, Global Environ. Change 42 (2017) p226–p236.
[18] J.M.N. Djomo, F. Sikod, The effects of human capital on agricultural productivity and farmer's income in Cameroon, Int. Bus. Res. 5 (4) (2012) 134.
[19] M. Kassie, M. Jaleta, B. Shiferaw, F. Mmbando, M. Mekuria, Adoption of interrelated sustainable agricultural practices in smallholder systems: evidence from rural Tanzania, Technol. Forecast. Soc. Change 80 (2013) 525–540.
[20] Y. Anley, A. Bogale, H.G. Abebe, Adoption decision and use intensity of soil and water conservation measures by smallholder subsistence farmers in Dedo districst, Western Ethiopia, Land Degrad. Dev. 18 (3) (2007) 289–302.
[21] B. Bayard, C.M. Jplly, Environmental perceptions and behavioral change of hillside farmers: the case of Haiti, Farm and Business – The Journal of the Caribbean Agro-Economic Society 7 (533–2016-38353) (2007) 122–138.
[22] H. Rahman, Y.M. Ginting, E. Elfindri, The Impact of social capital on the role of knowledge management system in the creative industry in getting sustainable competitive advantage, Journal of Benefits 5 (2) (2020) 187–201.
[23] R. Pandey, S.K. Jha, J.M. Alatalo, K.M. Archie, A.K. Gupta, Sustainable livelihood framework-based indicators for assessing climate change vulnerability and adaptation for Himalayan communities, Ecol. Indicat. 79 (2017) 338–346.

[24] G.E. Neves, C.P. Moraes, G.M. Santos, Ancient and traditional agriculture in South America: tropical lowlands. Book: "Oxford Research. Encyclopedia of Environmental Science, 2020.
[25] Kostas Alexandridis, Assessing cognitive and social attitudes toward environmental conservation in coral reef social-ecological systems, Soc. Sci. 7 (7) (2018) pp.1–32, June.
[26] N. To The, A. Nguyen Tuan, Efficiency and adoption of organic tea production: evidence from vi xuyen district, ha giang province, Vietnam, Asia-Pac J Reg Sci 3 (2019) 201–217.
[27] R.P. Neupane, K.R. Sharma, G.B. Thapa, Adoption of agroforestry in the hills of Nepal: a logistic regression analysis, Agric. Syst. 72 (2002) p177–p196.
[28] T. Nguyen-Anh, D. Nong, S. Leu, N. To-The, Changes in the environment from perspectives of small-scale farmers in remote Vietnam, Reg. Environ. Change 21 (2021) 1–17.
[29] C.V. Ortega, P. Esteve, B. Irene, T.E. Downing, A hydro-economic model for the assessment of climate change impacts and adaption in irrigated agriculture, Ecol. Econ. 120 (2015) 49–58.
[30] Zhen Liu, W. Ma, P. Liu, Y. Zhang, X. Li, Farmers' risk attitudes and pesticide use decisions: evidence from field experiments in China, J. Environ. Manag. 47 (4) (2018) 223–231.
[31] P. Spanoghe, V.B. Sigrid, H. Ihab, J. Liesbeth, D.V. Melanie, Food safety issues in fresh produce: bacterial pathogens, viruses and pesticide residues indicated as major concerns by stakeholders in the fresh produce chain, Food Contrlol 32 (1) (2013) 190–197.
[32] H.-G. Pham, S.-H. Chuah, S. Feeny, Factors affecting the adoption of sustainable agricultural practices: findings from panel data for Vietnam, Ecol. Econ. 184 (2021) 107000.
[33] L.L. Villamil, Y. Liang, R.E. Galt, Exploring the drivers of farmer adoption of organic farming practices in the United States, Agroecology and Sustainable Food Systems 42 (3) (2018) 252–276.
[34] D. Läpple, T. Van Rensburg, Adoption of organic farming: are there differences between early and late adoption? Ecol. Econ. 70 (7) (2011) 1406–1414.
[35] Nawab Khan, Ram L. Ray, Shemei Zhang, Evans Osabuohien, Muhammad Ihtisham, Influence of mobile phone and internet technology on income of rural farmers: evidence from Khyber Pakhtunkhwa Province, Pakistan, Technol. Soc. 68 (2022) 101866.
[36] N. Arunrat, N. Pumijumnong, Practices for reducing greenhouse gas emissions from rice production in Northeast Thailand, Journal of Agricultural 7 (1) (2017).
[37] Kloppenburg Jack, Social theory and the de/reconstruction of agricultural science: local knowledge for an alternative agriculture, Rural Sociol. 56 (4) (1991) 519–548.
[38] T. Markussen, F. Tarp, Political connections and land-related investment in rural Vietnam, J. Dev. Econ. 110 (2014) 291–302.
[39] F.G. Gachango, L.M. Andersen, S.M. Pedersen, Adoption of voluntary water-pollution reduction technologies and water quality perception among Danish farmers, Agric. Water Manag. 158 (2015) 235–244.
[40] I. Carmona, M.G. Dannie, M.A. Soriano, J.M. Murrilo, What do farmers mean when they say they practice conservation agriculture? A comprehensive case study from southern Spain? Agric. Ecosyst. Environ. 213 (2015) 164–177.
[41] Jules Pretty, Agricultural Sustainability: Concepts, Principles and Evidences, 2007.
[42] Zhan-biao Wang, Cheng-sheng Meng, Jing Chen, Fu Chen, Risk assessment of crop production amid climate change based on the priciple of maximum entropy: a case study of winter wheat production on the North China Plain, Int. J. Plant Prod. 13 (2019) 275–284.