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High-tech agriculture in Vietnam: Drivers for farmers' investment intention

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Abstract:

Purpose - The advantages of high technology in production are gaining farmers' attention; however, they face obstacles when transforming from traditional production to high-tech agriculture. This study aims to explore the factors affecting the intention to invest in high-tech agricultural production in Vietnamese rural households. The paper focuses on the impact of benefit perception, risk aversion, land use rights, access to credit, and market access on the investment intentions of farmers in high-tech agriculture.

Design - The study uses a face-to-face survey approach. Data were collected from 175 households in the Red River Delta in Vietnam.

Findings - Results show that benefit awareness and risk aversion play a key role. In addition, the study points out a positive influence of education, land use rights, access to credit, and access to consumption markets on households' investment intentions.

Practical implications - Our findings raise some policy issues to encourage the transition towards high-tech agriculture. First, information about the benefits of high-tech adoption should be conveyed to farmers through different channels. Second, production cooperation between farmers and enterprises is promoted. Third, people's access to credit sources to invest in agricultural production, especially preferential loan programs, should be supported. Fourth, agricultural workers should be offered training programs to improve farming techniques, as well as skills in operating and maintaining high-tech machinery and equipment. Fifth, appropriate policies should be designed to promote the development of the agricultural land market, thereby increasing access to and accumulation of land.

Originality - Although research on the drivers for investment in high-tech agricultural production receives widespread attention in many countries, studies on the same topic in Vietnam are currently limited. The influence of typical factors, including benefit awareness, risk aversion, land use rights, and participation in production linkages, has not been mentioned in studies in Vietnam, which will be comprehensively investigated in the paper. Moreover, the paper provides policy implications for promoting investment in high-tech agricultural production in Vietnam.

Keywords - Binary logit model, high-tech agriculture, investment intention, rural households, Vietnam.

Paper type - Research paper.

1. Introduction

After outstanding achievements in Doi Moi in the early 90s, Vietnam's agricultural sector is facing challenges. Agricultural growth has gradually declined in recent years in accordance with farmers' productivity and income from agricultural production activities (Dung *et al.*, 2018; Ho *et al.*, 2016). The competitiveness of Vietnamese agricultural products is relatively limited, while farmers are confronted with the increase in input prices and natural disaster risks. Several reasons contribute to the competitiveness

decline: traditional production practices with outdated farming techniques (Nguyen *et al.*, 2021) and the overuse of chemical fertilizers and pesticides (Do *et al.*, 2022; Minh *et al.*, 2017). Moreover, higher incomes in the non-agricultural sector lead to a reduction in rural people's interest in agricultural livelihoods, which is shown by the rise in abandoned land in recent years (Phung and Nguyen, 2023). In this context, boosting productivity and improving competitiveness is of importance to Vietnam's agricultural sector to maintain sustainable development and ensure food security.

In the process of industrialization, Vietnam is facing a shrinking agricultural land because of infrastructure construction and urban development (Tran *et al.*, 2021). In addition, the issues of land fragmentation and small-scale households are barriers to the modernization of the agricultural sector (Chu *et al.*, 2021; Phung, 2021; Tru *et al.*, 2020). Therefore, the application of high-tech agricultural practices to create breakthroughs in productivity and product quality is an essential need for the Vietnamese agricultural sector.

Compared to traditional production, the application of high technology in agricultural production has outstanding advantages. It does not only increase productivity on the same arable land but also improves the quality of agricultural products and effectively protects the environment by reducing the use of agrochemicals (Vu *et al.*, 2021; Wolf and Terrell, 2016; Sarkar *et al.*, 2023; Sangwanna *et al.*, 2024). Moreover, high-tech agriculture gains a higher level of trust from domestic consumers (Le *et al.*, 2020).

In spite of the benefits of high-tech agricultural models, their application is facing difficulties, such as the choice of suitable technologies to implement and the acceptance of farmers on this sophisticated technology (Mondal and Basu, 2009). There are many barriers for smallholder farmers in the transition to high technology. Specifically, financing and access to credit, labor responsiveness to new technologies, land fragmentation, and market access are the key obstacles (Lachman and López, 2019). Compared to traditional practices, high-tech production requires high initial costs, creating a financial burden for households (Hoang, 2021), leading to hesitance in investment decisions (Chen *et al.*, 2018; Ramaswami, 1992).

Although research on the drivers for investment in high-tech agricultural production receives widespread attention in many countries (see, for example, Baffoe-Asare *et al.*, 2013; Mwangi and Kariuki, 2015), studies on the same topic in Vietnam is currently limited (Luu, 2020; Vu *et al.*, 2021), the adoption of high-tech agriculture has captured farmers' interests in Vietnam. However, the participation rate is still very low (Lam, 2020). Farmers doubt switching from traditional production to high-tech agriculture because they are concerned about the risks of investment (Yen, 2022). Therefore, understanding the factors driving rural households to invest in high technology in agricultural production is of practical significance, which is the main investigation of the paper.

The paper is based on a survey of households in the Red River Delta region, which is the key agricultural production area in Vietnam and is undergoing rapid urbanization. This densely populated area has a higher per capita income than the national average, therefore being a potential market for high-tech agricultural products (Tran *et al.*, 2021). The paper focuses on the impact of benefit perception, risk aversion, land use rights, access to credit, and market access on the investment intentions of farmers in high-tech agriculture. The findings support policies that promote the investment motivation of farmers in high-tech production, leading to an increase in competitiveness in the agricultural sector.

The structure is as follows. Section 2 presents a literature review on factors affecting the motivation of high-tech investment in agricultural production of farmers. The research methodology and results are provided in Sections 3 and 4, respectively. Section 5 concludes and implies policy recommendations.

2. Literature review

By synthesizing and critically evaluating existing research in these areas, a literature review on high-tech agriculture can provide valuable insights into the state-of-the-art gaps in knowledge and policy action in this rapidly evolving field. The factors influencing investment choices for technology in agricultural production are the subject of extensive discussion. Whether or not to invest in new technology is a farmer's choice and depends on individual characteristics, including education, gender, or age (Mwangi and Kariuki, 2015). Other studies pointed out external influences, including technology features, socioeconomic peculiarities, and institutional environment (Muzari *et al.*, 2012; Uaiene, 2011). In the following, three groups of factors affecting the intention to invest in high-tech agriculture are categorized: (i) demographic characteristics, (ii) people's perception of technology, and (iii) socio-economic and institutional environment.

2.1. Demographic characteristics

Household characteristics are factors that can influence farmers' high-tech investment decisions. In addition to general demographic information, for example, the number of household members or the number of people of working age, researchers are often interested in information about the head of household, who plays an important role in the household's production and business activities, including age, gender and educational attainment in developing countries, for example, in Western Kenya (Mignouna *et al.*, 2011), India (Mittal and Mehar, 2016) and Ghana (Doss and Morris, 2000).

The influence of age on technology investment intentions is shown to have mixed evidence. According to Mignouna *et al.* (2011), older farmers tend to have more experience in production and, therefore, are better able to evaluate new technologies, and they tend to choose more environmentally friendly technologies than younger farmers. However, according to Barrera *et al.* (2005), older householders tend to be risk-averse, so the motivation to invest decreases significantly with age, especially for those types of investments that are long-term and require high costs. On the other hand, younger households are less risk-averse and more willing to experiment with new technologies (Wollni and Andersson, 2014). Therefore, the motivation to invest in agriculture may differ between household age groups.

Similarly, the influence of gender on high-tech investment intentions varies across studies. According to Mwangi and Kariuki (2015), in countries where agricultural technologies are considered vital ways of poverty relief, men have more opportunities to control household productive resources; the influence of gender on technology investment intentions is an issue that needs to be considered. Research by Obisesan (2014) shows that male householders are significantly more motivated than women to invest in cassava production technology in Nigeria. However, research by Doss and Morris (2000) shows no gender differences in households' decisions to use improved maize varieties in Ghana.

Regarding the role of education, many researchers emphasize that education increases farmers' awareness of technology and especially increases the uptake of new technologies (Mignouna *et al.*, 2011; Wollni and Andersson, 2014). For example, research by Waller *et al.* (1998) shows that educational attainment has a positive effect on farmers' willingness to experiment with new technologies in potato production in the U.S. state of Ohio. More recently, studies by Dung *et al.* (2018) and Vu *et al.* (2021) have also found evidence of the positive impacts of head education on rural households' intentions to apply high-tech agriculture in the Mekong and Red River Delta of Vietnam. However, Despotović *et al.* (2019) have shown that education does not have a significant influence on decisions to apply new technologies in pest treatment to crops in Serbia. Education may even reduce the incentive to access new technologies, as higher levels of education also provide more opportunities to transition to non-agricultural jobs, which is common in industrializing economies (Uematsu and Mishra, 2010).

2.2. Technology awareness

Awareness of the suitability of new technologies is one of the prerequisites for forming investment intentions, especially in developing countries, as it enables farmers to understand the benefits of new technologies, as well as the risks that may be encountered in the investment process (Mwangi and Kariuki, 2015; Abdullah *et al.*, 2024). The benefits of high-tech investment over traditional manufacturing are mentioned in many aspects, such as higher productivity, improved product quality, and especially being able to better meet the diversity of market needs (Broad *et al.*, 2022). Besides, risk aversion is a negative emotion when ordinary people do not really believe in the effects that high technology can bring (Dung *et al.*, 2018) because the initial cost of investing in high technology is generally very large (Anichkina *et al.*, 2019).

Benefit awareness and risk aversion are factors mentioned in many studies on the motivation of people to invest in high technology in many countries. Overall, studies are consistent with the thesis that increased perceptions of benefits contribute to a significant increase in farmers' intention to invest in high technology (Despotović *et al.*, 2019; Sinja *et al.*, 2004). In addition, risk aversion is also a significant hindrance to farmers' high-tech investment decisions, including concerns about high investment costs (Mwangi and Kariuki, 2015), difficulty in accessing credit, or lack of knowledge to meet the requirements of new technologies (Wekesa *et al.*, 2003) are key issues.

2.3. Economic, social, and institutional factors

According to Bonabana-Wabbi (2002), the land is an important asset for deploying new technology, as large-scale farms are often suitable for using high-tech machinery due to scale efficiency. Furthermore, it is often easier for households who own large farms to set aside a portion of their land to experiment with new technologies, thus having an advantage in access to technology (Uaiene, 2011). However, households that own smaller farms are often more motivated to adopt new technology as a solution to agricultural land scarcity (Yaron *et al.*, 1992). Therefore, the influence of farm size on the motivation to invest in new technology is an issue that has not yet reached a consensus among researchers (Bonabana-Wabbi, 2002; Kariyasa and Dewi, 2013).

One of the other important factors influencing the motivation for high-tech agricultural investment is the financial ability to secure initial investments. This is one of the biggest obstacles smallholder farmers face, as their financial capacity is often very limited (Mwangi

and Kariuki, 2015). Therefore, factors related to the financial capacity of households include household income (Diiro, 2013), ability to borrow credit (Muzari *et al.*, 2012; Uaiene, 2011), and collateral for loans (Nguyen, 2020; Zahonogo and Séogo, 2019) is often of widespread interest in studies of motivation for investing in technology. This is because financial shortfall is often an important barrier for farmers when considering investment, as high-tech investment costs are often very large (Vu *et al.*, 2021).

In addition to the impact of economic factors, the motivation for high-tech investment in households is also influenced by the social connection between farmers and groups, production chains, and community organizations. This connection helps not only to share ideas, information, and inspiration (Mignouna *et al.*, 2011) but also to support farmers in the implementation and operation of new technologies (Genius *et al.*, 2014). Empirical studies by Uaiene (2011) and Faleye and Afolami (2020) have shown that farmers who are members of agricultural associations are more likely to adopt new technologies because they are aware of the benefits and learn how to invest in new technologies. In addition, the motivation of households to invest in high technology is also positively influenced by incentives and support from the government, such as policies to support credit loans or financing programs to promote high-tech investment (Muzari *et al.*, 2012).

The above analysis has shown the influence of many different factors on the motivation of high-tech investment in agricultural production, some of which have been mentioned in recent studies in the Mekong and the Red River delta of Vietnam such as Luu (2020); Vu *et al.* (2021) or Dung *et al.* (2018). However, the influence of typical factors such as benefit awareness, risk aversion, land use rights assurance, as well as participation in production linkages has not been mentioned in studies in Vietnam, although they are found to play a critical role in affecting the farmers' decision on high-tech production adoption in developing agricultural countries. An understanding of the influence of these factors is important, enabling to explain the barriers that Vietnamese households are facing in the transition to access high technology in agricultural production. This also helps to elicit necessary policy proposals to accelerate the deployment of high technology in this field.

3. Materials and method

3.1. Research design

The data used in the study was collected from a face-to-face survey conducted by the authors in the Red River Delta provinces, including Hanoi, Vinh Phuc, and Thai Binh. The application of high-tech agriculture is relatively new in Vietnam; the practice is more common in areas adjacent to big cities due to the demand for high-tech agricultural products. Thus, the participants of the research are suburban households who reside close to large urban areas, including Hanoi, Vinh Phuc, and Thai Binh. Their main markets are urban residents. These subjects have the common characteristic of having access to both technology thanks to being located near large cities and having the potential markets for consuming high-tech agricultural products.

The sample was randomly selected and included households living in rural areas engaged in agricultural production. Respondents are heads of households who play an important role in their production and business activities. Respondents are selected

according to groups based on demographic characteristics (gender, age, education) and place of residence. A total of 198 responses were obtained, of which 23 missed essential information and were excluded from the study, while the remaining 175 votes were used for analysis. The sample size is different between the three provinces according to the level of the market, in which Hanoi is the capital, Vinh Phuc is a satellite city, and Thai Binh is a smaller province.

Some basic information of the study sample is presented in Table 1.

Table 1.
Description of the sample

Respondent information	Variable	Observations	%
Gender	Female	61	34.9
	Male	114	65.1
Age	Under 45 years old	81	46.3
	From 45 to 60 years old	65	37.1
	Over 60 years old	29	16.6
Education	Primary school and below	5	2.9
	Secondary school to High school	40	22.8
	Vocational training or higher	130	74.3
Province/ City	Ha Noi	84	48.0
	Vinh Phuc	52	29.7
	Thai Binh	39	22.3

Source(s): Calculated by the authors.3.2. Estimation models

This paper uses a logit model to explore factors affecting the adoption of high-tech agriculture practices to provide valuable insights for decision-making in agricultural policy and practice. The use of probit and logit models is proper in analyzing which of the two options take place (Hoetker, 2007). One of the limitations of logit and probit models is the assumption of independence of irrelevant alternatives (i.d), meaning a mutual exclusion of the error terms of choices (Greene, 2003; Mittal and Mehar, 2016). In our case, there might be a correlation among the random error components of the information sources since there is a mutual exclusion of the choices among different information sources. To deal with the limitation, we consider using a multivariate model that allows for the possible contemporaneous correlation in the choice to access the four different sources simultaneously.

Numerous studies on the factors influencing the implementation of high-tech agriculture production have applied this method (see, for example, Jenkins *et al.*, 2011; Mittal and Mehar, 2016). It enables an increase in estimation efficiency and potential simultaneous correlation in the selection of scenarios (Mittal and Mehar, 2016).

In this model, Y is a binary variable, taking a value of 1 if the household intends to invest in high-tech agriculture and zero if vice versa. The binary logit model in assessing the impact of factors on farmers' investment intentions is as follows:

$$p = P[Y = 1|X] = \frac{e^{\alpha+X'\beta+u}}{1+e^{\alpha+X'\beta+u}} (1)$$

Where X is the explanatory vector, including factors that affect the investment intentions of farmers; u is a random error; α,β are the parameters to be estimated.

The model (1) turns out to be:

$$\ln\left(\frac{p}{1-p}\right) = \alpha + X'\beta + u \quad (2)$$

Where the odds ratio $\frac{p}{1-p}$ indicates the likelihood of an event *Y=1* (household intends to invest in high-tech agriculture) is equal to how many times the opposite is the case; the coefficient β represents the effect of *X* on the value of *ln(odds)*. The higher the value of *ln(odds)* implies the greater the *odds* ratio.

Variable name	Variable definition	Calculation/ Unit of Measurement	Reasons for the inclusion of variables in the model
Benefit	The level of awareness of the benefits of high-tech agriculture investment compared to conventional	Synthesized by EFA method with 5 component scales of benefit perception, including (i) productivity, (ii) quality, (iii) favorability, (iv) environmental friendliness, and (v) operational cost savings. (For details, see Table A1)	Awareness of the benefits that high-tech agriculture brings can increase the motivation of households to invest in renewable energy.
Risk	The level of concern about the risks of investing in renewable energy compared to usual	Synthesized by the EFA method with 5 component scales of risk aversion, including (i) initial cost, (ii) access to land, (iii) access to consumer markets, (iv) the responsiveness of domestic workers, and (v) access to credit. (For details, see Table A1)	Concerns about investment risks may reduce the motivation of households to invest in renewable energy.
Age	Age of head of household	Variables with three categories: 1-Under 45 years old 2-From 45 to 60 years old 3-Over 60 years old	At different ages, interest in high-tech agriculture investment may vary.
Female	Gender of the head of household	Binary variable: 0- Male 1- Female	The level of interest of men and women in renewable energy investment may vary.
Edu	Education the head of household	Variables with three categories: 1- Primary and below 2- Lower secondary school to the end of upper secondary school 3- Vocational training or higher.	Education helps increase awareness, so the level of interest in high-tech agriculture can vary.
Red_book	The percentage of agricultural land use rights	%	Land use rights help increase access to capital and reduce concerns when investing in high-tech agriculture.
Credit	Access to credit	Pseudobinary variables: 1- Households have access to credit 0- Households are not entitled to access credit.	Access to credit helps increase financial capacity, facilitating investment in high-tech agriculture.
Market_link	Join the chain of product consumption links	Pseudobinary variables: 1. Households participating in the chain of link consumption of products 0- Households not participating in the chain of links	Joining the link chain helps increase access to the consumption market, creating a trust for households to increase investment in production.

Table 2.
Variable definition

In Table 1, the benefit variable is used to assess the impact of benefit perception, while the risk variable aims to assess the impact of risk perception on farmers' intentions to invest in agriculture. The age, female, and edu variables control for age, gender, and head of household education, respectively, which are fundamental factors that reflect the characteristics of household demographics. Finally, variables red_book, credits, and market_link are used to consider the impact of land use right certification, credit access, and product consumption chain access on renewable energy investment intentions.

The Cronbach's Alpha accreditation shows that the scales selected to measure farmers' perception of the benefits and risks of high-tech agriculture investment are appropriate and ensure reliability (Table A2). Next, the EFA method was used for this group of scales, resulting in one composite scale representing the perception of benefit and two synthetic scales representing the anxiety of households when investing in renewable energy (*Risk_1* and *Risk_2*) (Table A3). These aggregate scales will be used as explanatory variables in the model of assessing factors impacting farmers' high-tech agriculture investment intentions, as mentioned.

Some descriptive statistics of the variables in the study model are reported in Table 3.

Table 3.
Descriptive statistics of variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Y	175	0.760	0.428	0	1
Benefit	175	0.025	1.021	-4.610	1.393
Risk1	175	-0.037	1.024	-2.783	2.098
Risk2	175	0.036	1.003	-3.078	2.240
Age	175	1.703	0.737	1	3
Female	175	0.349	0.478	0	1
Edu	175	2.714	0.513	1	3
Red_book	175	57.447	43.491	0	100
Credit	175	0.543	0.500	0	1
Market_link	175	0.474	0.501	0	1

4. Results

Table 4 presents the estimation of model (1). The positive and statistically significant coefficient for *Benefit* shows that the perception of the benefits brought by high-tech agriculture is a factor that has a positive impact on the investment intentions of farmers. In the context of increasingly inefficient traditional agricultural production, the superiority in productivity, product quality, competitiveness, operating costs as well as environmental safety of agriculture will be an important motivation for households to change production methods towards applying high technology to achieve higher production efficiency. This finding is aligned with previous research that pointed out the important role of benefit awareness in the adoption of high-tech production, for example, in India (Mittal and Mehar, 2016), Ghana (Doss and Morris, 2000), Serbia (Despotović *et al.*, 2019).

The estimation coefficient of *Risk1* is negative and statistically significant but not for the coefficient of *Risk2*, suggesting that concern about possible risks was a factor that reduced the motivation of farmers to invest. According to Abdullah *et al.* (2024), perceived risks can significantly impact high-tech agriculture by influencing farmers' decision-making processes, adoption rates of new technologies, and overall investment behavior. In particular, concerns about difficulties in access to land, access to credit, and capacity of labor (included in the composition of *Risk1*) are more concerned by

farmers, while there is no similar evidence for initial investment costs or problems accessing consumer markets (included in the composition of *Risk2*). Moreover, as pointed out by Dung *et al.* (2018), farmers with large household sizes and relatives tend to be more confident in applying high-tech production since the risk is distributed over more people.

In terms of the influence of demographic factors, the coefficient of *edu_3* is positive and statistically significant, showing the influence of education on investment intentions. Householders with vocational training and university education or higher are more motivated to invest in agriculture than householders with primary education or below. This is because highly educated householders often have a better awareness of the advantages of high-tech agriculture, such as improving the competitiveness of products to reach potential markets and, therefore, achieving higher profits. Moreover, education enables farmers to have the ability (Mignouna *et al.*, 2011) and select the reliable and appropriate information to apply the new technology (Namara *et al.*, 2013). The coefficient of *edu_2* is not statistically significant, so there is no difference in this figure for the householders with education from middle school to high school. On the influence of age and gender, the coefficients of *age_2*, *age_3*, and *female* are not statistically significant, so there is no evidence of differences between households by age group and gender in farmers' investment intentions. Although the influence of age on the adoption of high-tech agriculture is unexpected, it can be explained by mixed results in the previous studies. For example, older farmers expressed better ability than younger ones in assessing information about technology thanks to their experience (Mignouna *et al.*, 2011). However, they would have a high level of risk aversion, leading them to be less willing to invest on new technologies (Mauceri *et al.*, 2005). The story remains similar to the mixed role of gender in decision to adopt high-tech production. Specifically, studies suggested no significant impact of gender and technology implementation decisions (Doss and Morris, 2000), while others pointed out a positive influence (Mignouna *et al.*, 2011).

Variable	Marginal Effect	Variable	Marginal Effect
Benefit	0.046*	*Edu_2*	0.151
	(0.025)		(0.148)
Risk1	-0.050**	*Edu_3*	0.240*
	(0.025)		(0.142)
Risk2	0.016	*Red_book*	0.002***
	(0.031)		(0.001)
Age_2	0.018	*Credit*	0.303***
	(0.061)		(0.060)
Age_3	0.092	*Market_link*	0.144***
	(0.071)		(0.059)
Female	-0.006		
	(0.057)		
No of obs:	*175*		

Table 4.
Estimated result

*Note: The number in parentheses is a standard error, and *, **, *** denote significance levels of 10%, 5%, and 1%, respectively.*

The coefficient of *red_book or land use certificate* is positive and statistically significant, implying that the higher the percentage of agricultural land use rights, the greater the motivation for farmers to invest in agriculture. As mentioned, owning a land use right not only helps households to have better access to credit – for example, they can mortgage this paper to borrow from banks – but also acts as collateral,

helping to reduce concerns about risks when investing in renewable energy. Land use certificates play a critical role in promoting high-tech agriculture by providing farmers and investors with the security, confidence, and incentives needed to invest in advanced technologies, infrastructure, and sustainable farming practices. By ensuring secure land tenure, governments can unlock the potential of high-tech agriculture to enhance productivity, improve livelihoods, and promote sustainable development in rural areas. This result is similar to previous findings (see, for example, Dung *et al.*, 2018), confirming the important role of land tenure status in the application of new technologies. It is thanks to the fact that the benefits acquired from high-tech production implementation accumulate over a long period of time.

The coefficient of *credit* variable is positive and statistically significant, as in previous studies (Dung *et al.*, 2018), indicating that access to credit has a positive influence on farmers' intentions to invest in agriculture. Credit plays a critical role in promoting high-tech agriculture by providing farmers and agribusinesses with the financial resources needed to invest in advanced technologies, infrastructure, and capacity-building initiatives. This is in line with the reality that the initial investment cost for procurement of high-tech machinery is usually quite large. Thus, the finance is often the top concern when intending to invest. In the absence of financial capacity and access to loans, farmers often have the option of switching to a more suitable form of investment or continuing to pursue traditional production methods.

Finally, the positive and statistically significant coefficient of *market_link* implies that market access plays an important role. The market serves as a powerful driver for promoting high-tech agriculture by aligning incentives, stimulating innovation, and fostering the adoption of technologies and practices that enhance productivity, sustainability, and competitiveness in the agricultural sector (Mittal and Mehar, 2016). Those households that have built linkages to consume products have a higher incentive to invest in renewable energy than the other group. In the context that the agricultural market is not strictly censored, the recognition and brand protection for "clean" agricultural products still have many deficiencies, agricultural products will have difficulty in competing with traditional products. This is because the initial investment cost is usually quite large. To be profitable, renewable energy products need to be consumed at a high price.

5. Conclusions and Policy implications

The paper provides an empirical study analyzing the influences on the investment intention of high-tech agricultural production of Vietnamese rural households. In the context that Vietnam's agricultural sector is striving to promote the transformation of production methods towards a modern and sustainable direction, it is necessary and meaningful to recognize the influence of these factors. Applying a binary logistic regression model, the research results show that education level, awareness of the renewable energy benefits, access to land use rights, access to credit, and access to the agricultural consumption chain are factors that positively influence investment intention in renewable energy. In contrast, concerns about risks in the investment process are significant obstacles.

The research results show that, in order to encourage the transition from traditional

agricultural production to high-tech agriculture, current policies in Vietnam should focus on the following issues. First, information about the benefits of high-tech adoption should be conveyed to farmers through different channels to enable them to be better aware of the benefits of high-tech agriculture, thereby creating motivation to change traditional production methods. Second, it is necessary to promote production cooperation between farmers and enterprises, thereby building production and consumption linkages to expand markets for agricultural products. This also reduces concerns about the possible risks of high-tech investment in agricultural production. Third, it is necessary to have policies to support people's access to credit sources to invest in agricultural production, especially preferential loan programs, so that people have the financial ability to invest in production technology. The Vietnamese government can provide subsidies and incentives to financial institutions that offer loans for high-tech agriculture projects. Specialized credit programs should be established to offer flexible repayment terms, longer loan tenures, and lower interest rates to accommodate the longer payback periods specifically tailored to the needs of high-tech agriculture. These partnerships between government agencies, financial institutions, technology providers, and agricultural organizations can leverage the expertise and resources of various stakeholders to design financial products that meet the unique needs of farmers and agribusinesses. Fourth, to contribute to reducing the concerns about the risk of applying high-tech production; it is necessary to support agricultural workers through training programs to improve farming techniques, as well as skills in operating and maintaining high-tech machinery and equipment. By implementing these comprehensive training programs, Vietnam can empower farmers to embrace high-tech agriculture practices, enhance their productivity and resilience, and contribute to the sustainable development of the agricultural sector. Training on the use and maintenance of advanced farming equipment like drones, GPS-guided machinery, and automated irrigation systems is crucial. It is also necessary for teaching farmers how to collect, manage, and analyze data from various sources like sensors, satellite imagery, and weather stations. In addition, other training contents such as water recycling and conservation methods, precision nutrient application using variable rate technology, renewable energy options such as solar panels and wind turbines for farm operations, budgeting, and financial planning for technology adoption are also important. Fifth, it is necessary to have appropriate policies to promote the development of the agricultural land market, thereby increasing access to and accumulation of land. For example, promoting the issuance of agricultural land use right certificates can help ensure the legality of agricultural land use concession transactions, as well as collateral for people to more easily access loans. In addition, it is necessary to increase autonomy for people in the process of using agricultural land. For example, it is necessary to adjust the land area required to grow rice at an appropriate level so that people can be proactive in choosing crops as well as production technology to maximize benefits. By integrating these considerations into land policy frameworks, the government can create an enabling environment for the development of high-tech agriculture, fostering innovation, productivity, and sustainability in the agricultural sector. The government can promote land incentives for high-tech agriculture through various ways, such as establishing programs that offer discounted or subsidized land leases for farmers engaging in high-tech agriculture, extending the land tenure for agricultural land, facilitating partnerships between landowners and farmers interested in implementing

high-tech farming practices, providing incentives for both parties. Land accumulation and concentration should be proposed through cooperatives to form large agricultural commodity production areas/zones and link with businesses. It should also encourage farming households to accumulate and concentrate land through voluntary participation in cooperatives. Moreover, enterprises should be encouraged to accumulate and concentrate land through subleasing agricultural land from farmers, receiving capital contributions in the form of land use rights from farmers, or leasing local land from land funds/land banks.

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Appendix:

	Scale	Name of variable	Scale value
Perceive benefit	High-tech production vs. traditional production:		
	1- Higher productivity	B1	1- Totally disagree
	2- Products of higher quality	B2	2- Disagree
	3- Products are more competitive	B3	3- No opinion
	4- Save more operating costs	B4	4- Agree
	5- More environmental safety	B5	5- Totally agree
Fear of risk	Concerns when investing in renewable energy:		
	1- Difficult to access land for deployment	R1	1- Totally disagree
	2- The employee fails to meet technical requirements	R2	2- Disagree
	3- Difficulty accessing credit	R3	3- No opinion
	4- The initial cost is beyond the ability to pay	R4	4- Agree
	5- The product is difficult to find a market for consumption	R5	5- Totally agree

Table A1.
Scales of benefit awareness and risk aversion

	Factors	Cronbach's Alpha	Corrected Item-Total Correlation
Benefit	B1	0.912	0.803
	B2		0.855
	B3		0.710
	B4		0.745
	B5		0.777
Risk	R1	0.765	0.436
	R2		0.407
	R3		0.636
	R4		0.653
	R5		0.557

Table A2.
Cronbach's alpha coefficient

KMO and Barlett's Test			
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.			0.813
Bartlett's Test of Sphericity		Approx. Chi-Square	971.349
		df	45
		Sig.	0.000
Total Variance Explained			
Component	Total	% of Variance	Cumulative %
1	3.856	38.560	38.560
2	2.492	24.917	63.477
3	1.043	10.425	73.902
Rotated Component Matrix[a]			
	1	**2**	**3**
	(*Benefit*)	(*Risk1*)	(*Risk2*)
B1	0.884		
B2	0.917		
B3	0.807		
B4	0.829		
B5	0.850		
R1		0.800	
R2		0.857	
R3		0.823	
R4			0.793
R5			0.850

Table A3.
EFA factor group of benefit perceptions and risk concerns

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