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Mixed method evaluation of factors influencing the adoption of organic participatory guarantee system certification among Vietnamese vegetable farmers

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Abstract

In markets where vegetables are commonly cultivated with heavy use of synthetic pesticides, it is particularly important for consumers to be able to identify genuine organic produce. Organic Participatory Guarantee Systems (PGS) certification offers smallholder farmers an affordable way to build trust among consumers and secure premium prices for their organic produce. In Vietnam, the demand for vegetables with no, or low, pesticide residues is growing. The attractiveness of PGS certification should increase accordingly, but the number of organic PGS certified farmers in Vietnam are stagnating or even decreasing. The aim of this study is to explain this paradox by investigating the factors that influence the adoption of organic PGS certification among Vietnamese vegetable farmers. We follow a mixed methods approach, combining a qualitative analysis of farmer interviews ($n = 62$) and a quantitative analysis of a farm survey data ($n = 434$) using a sample selection model that estimates adoption contingent on farmers' awareness of PGS certification. Drawing on the Unified Theory of Acceptance and Use of Technology, we found that social relationships and positive attitudes towards farming and the environment drive the adoption of organic PGS. Barriers include insufficient knowledge of organic farming techniques, labour shortages, and ageing farmers. At the systemic level, support by (non-)governmental institutions facilitates adoption, but challenges such as lower yields and limited access to premium markets remain. To promote organic PGS among Vietnamese vegetable farmers, efforts should focus on disseminating organic farming techniques that boost yields, alleviate labour demands, and ensure secure markets for premium-priced organic vegetables.

Keywords Certification adoption · Smallholder farmers · Pesticides · Organic agriculture · Heckman model · Qualitative analysis

Introduction

Global food systems are estimated to generate more than twice the external health and environmental costs of the market value of food (von Braun and Hendriks 2023). This highlights the need for transformation towards a global food system that does not harm people or the environment. A major source of health and environmental costs is the use and overuse of (highly toxic) synthetic pesticides, which is particularly pronounced in high-value, pest-sensitive crops, such as vegetables (Asian Development Bank 2023; Hoi et al. 2016; Praneetvatakul et al. 2013; Wanwimolruk et al. 2016).

Although this is a worldwide phenomenon, it is particularly relevant to Southeast Asia, where vegetables form a

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major part of the diet of local populations (Hoi et al. 2016; Schreinemachers et al. 2020) and where synthetic agrochemicals are cheap, readily available, and applied excessively, with pesticide use surpassing the economic optimum by up to a factor of four (Grovermann et al. 2013; Schreinemachers et al. 2020). The phenomenon of excessive pesticide use has long been recorded in Vietnam, where food scandals due to pesticide residues are frequently reported in the media (Nguyen-Viet et al. 2017; Rikolto International, n.d.; World Bank 2017) and consumer trust in the safety of vegetables is low (Moustier and Loc 2015; Ngo et al. 2020). Vietnamese consumers primarily fear the health risks associated with the excessive and improper use of pesticides (Wertheim-Heck et al. 2014).

Voluntary third-party certification schemes, such as GLOBALG.A.P. and organic, while not direct food safety instruments, contribute to the necessary transformation and address food safety concerns (Home et al. 2017; Tandon et al. 2020). One aim of these certification standards is to change farmers' use of synthetic pesticides towards more sustainable options by internalising some of the external costs (von Braun and Hendriks 2023), or in the case of organic certification, eliminating their use altogether. However, one main criticism of these third-party certification schemes is that certification processes typically involve high costs, which represents an important barrier to adoption by smallholder farmers in low and middle-income countries (Oya et al. 2018).

Participatory Guarantee Systems (PGS) offer an alternative certification method for smallholder farmers who cater to domestic markets. PGS has been recognised by the International Federation of Organic Agriculture Movements (IFOAM) - Organics International as an alternative and complementary tool to third-party certification within the organic sector (IFOAM - Organics International, 2024). PGS principles and some of the current PGS initiatives have existed since the early days of the organic movement in the first half of the 20th century (Anselmi & Moura e Castro, 2023). The number of PGS initiatives and the producers certified by them has been steadily increasing across continents, with 1.3 million farmers globally organised in 323 PGS across 76 countries in 2022 (Anselmi & Moura e Castro, 2023). However, by 2020, PGS was legally recognised in the organic regulations of only 15 countries (Moura e Castro et al. 2021).

Given the Vietnamese market's growing demand for vegetables with no or low levels of pesticide residues (Ngo et al. 2019), organic PGS could offer an attractive option for farmers looking to differentiate their produce with pesticide-free and sustainability assurances. However, the number of Vietnamese organic PGS certified vegetable farmers is defying this expectation by stagnating or even decreasing (Willer et al. 2023), with a similar trend reported in other countries, such as Bolivia (Jacobi et al. 2023). Despite the long history of PGS, and its place in assuring consumers of organic produce, there has been insufficient systematic quantitative study into the factors that motivate PGS adoption by vegetable farmers.

The aim of this study is to investigate the reasons for the unexpected lack of adoption in Vietnam of a system that is claimed to bring direct benefits to smallholder farmers by a growing body of research (Hruschka et al. 2024). Specifically, we address the research question: Which factors encourage or discourage the adoption of organic PGS certification by vegetable farmers in Vietnam? We approach this question through a mixed methods approach that combines a qualitative analysis of semi-structured farmer interviews with the analysis of quantitative data from a structured representative farmer survey based on a sample selection model. In this way, the study contributes to the sparse, but growing, literature on the determinants of adoption of (organic) PGS certification, thereby contributing to the larger literature on the adoption of sustainability standards by smallholder farmers. The Vietnamese National Food Transformation plan aims at reaching 2.5% organic land area by 2030 (Vietnam office of agricultural affairs 2023). This study is thus also of clear relevance for practitioners and policy-makers in Vietnam and the wider region, where similar targets have been, or are likely to be, set.

Literature review

Vegetable production systems in Southeast Asia have faced significant problems with food safety in recent decades. This is mostly associated with the misuse and overuse of synthetic plant protection products (Schreinemachers et al. 2015). With growing demand for fresh vegetables in the Vietnamese capital Hanoi, vegetable cultivation in the peri-urban areas around Hanoi has been increasingly intensified. This includes substituting biological with chemical inputs, maintaining cropping patterns that deplete soils, and replacing low-input paddy and maize production by high-input vegetable systems (Thanh et al. 2021). These developments have decreased food safety and sustainability in vegetable production around Hanoi (Hoang 2020).

As a response, the Hanoi local government initiated the safe vegetable programme in the 1990s, aiming to encourage growth of safe vegetables (Hoi et al. 2009). Safe vegetables are those produced under specific conditions and procedures, including the strict adoption of integrated pest management practices, the careful use of low-toxicity inputs, such as pesticides, herbicides, and fertilisers, and the use of clean water for irrigation (Enthoven and Van den

Broeck 2021). The Hanoi program met with limited success and the target of growing safe vegetables on 20% of Hanoi's vegetable growing area was not achieved, with only 2% reached by 2008 (Hoi et al. 2009). The Vietnamese government then introduced the third-party verified VietGAP standard in 2008, aiming to promote good agricultural practices among (vegetable) farmers nationally.

Until 2018, only 0.2% of agricultural land and 4% of vegetables consumed in Vietnam were VietGAP certified (World Bank 2017). The standard remained unattractive to farmers due to limited demand for certified vegetables (Tung, 2016) and vegetable farming in peri-urban Hanoi remains highly input-intensive (Hoang 2020). Similar standards, such as Q-GAP in Thailand have similarly been shown to not, or only slightly, reduce the use of synthetic inputs (Amekawa 2013; Schreinemachers et al. 2012). Hoang (2020) explained the low demand for VietGap-certified vegetables in Vietnam with the finding that consumers possess a low understanding of food safety along with low trust, and instead rely on subjective measures to assess vegetable quality. Furthermore, the prevalence of trust-based relationships of actors along the value chain negatively influenced the adoption of VietGap-certification (Hoang 2020).

Production of safe vegetables is associated with higher costs for which farmers are compensated with a price premium (Ariadi et al. 2021). The lack of trust in VietGAP is at least partially attributed to a suspicion that dishonest traders may gain the price premiums for certified produce using fraudulent claims (Hoang 2020), which is a challenge that has been faced by the organic sector (Iannucci and Sacchi 2021). In the early days of the organic movement, certification was unnecessary because the organic industry was small, and the integrity of produce was "guaranteed" by trust: based on a direct relationship between the usually small-scale independent farmers and the consumers who met at the point of sale, such as at farmers' markets (Meirelles 2011). However, as the organic sector has grown, farmer-consumer relationships have become the domain of traders. Thus, institutionalised mechanisms of authenticity assurance are needed; a service that is provided by third-party organic certification (Home et al. 2017). Institutionalised third-party certification relies on standards that must be met along with an inspection regime to guarantee compliance, which unifies consumer perceptions and contributes to increasing the societal legitimacy of organic agriculture (Rahmann et al. 2017). However, it also implies that farmers at some point will need to decide whether to pursue certification, making it crucial to understand their adoption behaviour for effective agricultural policy design (Pannell and Zilberman 2020).

High certification costs (Home et al. 2017), paperwork and bureaucracy (Nelson et al. 2016), and indirect costs from increased labour or input requirements are major barriers to adopting third-party certification, giving wealthier smallholders and male farmers an advantage in joining certification schemes (Oya et al. 2018). Another criticism of third-party certification is that it carries a political dimension, being seen as an imposition by the global North on the global South (Nelson et al. 2016). Consequently, alternative approaches for food quality and safety assurance, including internal control systems (Suswadi et al. 2021), have been introduced by local governments, NGOs, and farmer cooperatives, with Participatory Guarantee Systems (PGS) prominent among these (Anselmi & Moura e Castro, 2023).

The advocated benefits of PGS include lower certification costs, reliance on trust and monitoring through social networks, enhanced farmer-buyer interactions, continuous capacity development for farmers, support with quality assurance in developing local value chains, and a democratic operation that incorporates local social and cultural contexts, thereby enabling community development and farmer empowerment (Home et al. 2017; Kaufmann et al. 2020; Loconto and Hatanaka 2017; Nelson et al. 2016; Rodrigues Hirata et al. 2021). Although PGS is not exclusively tied to organic agriculture and is applied in various systems and movements, such as the agroecology movement (Agroecology Fund, 2024) or with VietGAP (Enthoven and Van den Broeck 2021), many PGS initiatives still operate in line with organic farming principles. Thus, organic PGS encourage farmers to convert to organic farming and enable certification for those who might otherwise be excluded from the benefits of the organic system, such as organic price premiums (Bellante 2017; Home et al. 2017; Home and Nelson 2015).

However, PGS also encounter certain challenges. Many PGS rely on support from external institutions, such as NGOs and universities (Kaufmann et al. 2020), with Aoun et al. (2022) pointing out the need for PGS to have a clear business plan that allows it to become self-sustainable once the funding stops. Furthermore, while certification costs might be lower than third-party certification, the implicit costs in terms of time investment in the certification process, might be substantial and unevenly distributed among members (Kaufmann et al. 2023a). A further challenge is that the marketing of PGS certified products, which are often associated with a price premium, is difficult when targeting price sensitive consumers in low and middle-income countries (Jacobi et al. 2023). This highlights the importance of developing markets by building public support through consumer education campaigns; in many regions, such as Latin America, these are not consistently implemented (Hruschka et al. 2024). Despite these challenges, significant resources have been committed to promoting the development of PGS in Vietnam.

The Danish NGO Agricultural Development Denmark Asia (ADDA) and IFOAM– Organics International, financed through the Danish International Development Agency (DANIDA), established "PGS Vietnam" in 2008 as a local organic PGS. This step initiated Vietnam's organic agriculture movement, which was further promoted by the establishment of the Vietnam Organic Agriculture Association (VOAA) in 2012. Responding to the growing market and societal demand for organic agricultural products, the Vietnamese government has introduced several policies to boost the development of organic agriculture. In 2017, four National Standards on Organic Agriculture (TCVN 11041) were issued, followed by Decree 109/2018 on the development of organic agriculture (Bui 2022). These National Standards encompass general requirements for the production, processing, and labelling of organic products; organic crop production; organic animal husbandry; and requirements for organisations certifying organic products. TCVN 11,041 follows four principles of organic agriculture: Health, Ecology, Fairness, and Care. These TCVNs are largely harmonised with international and regional standards, while also suitable for Vietnam's specific conditions and practical application (MOST 2022).

Today, the PGS Vietnam standard has been approved by IFOAM– Organics International and the Vietnamese government's Decree on Organic Agriculture (Decree 109/2018/ND-CP) and exists alongside various international third-party standards (e.g. USDA and EU Organic) and the national organic standard TCVN 11,041. Within PGS Vietnam, farmers are organised in small groups, which mainly organise marketing. In the peri-urban areas around Hanoi, specifically the provinces of Hanoi, Hanam, and Hoabinh, there were 33 farmer groups and 181 PGS Vietnam certified farmers in 2021 (IFOAM - Organics International 2022). Several farmer groups form a cooperative, which cover administration tasks, such as certification and farmer training.

The number of organic farms certified under PGS in Vietnam reached its peak in 2018 with around 725 farm members (Ricolto 2018). Although recent evidence shows that membership of PGS Vietnam improves farm profitability, agroecological performance, and sales channel choices among vegetable farmers (Grovermann et al. 2024), the numbers of PGS Vietnam farmers has dropped to 704 (Willer et al. 2023). This allows the conclusion that intervention is needed if PGS are to survive within the Vietnamese agricultural system.

In the context of smallholder farmers, most literature has focussed on assessing the impact of export-crop third-party certification on diverse outcomes, including farmers' environmental, social, and economic performance (Oya et al. 2018). Far fewer studies have (quantitatively) identified the determinants of domestic-market third-party certification adoption. Using a quantitative approach, Krause et al. (2016) identified education as well as physical and social capital as important factors for Q-GAP adoption among horticulture farmers in Thailand.

Studies on the adoption of PGS certification have shown that PGS adoption is hindered by several challenges, including access to stable marketing channels with premium prices for organic produce (Bellante 2017; Enthoven and Van den Broeck 2023; Home et al. 2017) and increased time and labour demand associated with organic production and PGS requirements (Bellante 2017; Home et al. 2017; Hruschka et al. 2022). Furthermore, Hai et al. (2018) point out that PGSs cannot be successful without a stable market for their vegetables, but many Vietnamese farmers and group leaders have a limited business and marketing capacity. However, a diverse range of benefits might promote PGS adoption, including lower certification costs compared to third-party certification, market access and price premiums, community development and mutual support, access to technical training, preservation of indigenous culture, promotion of local products, access to high-quality food, and the direct consumer-producer relationship motivate PGS participation (Kaufmann et al. 2020; Hruschka et al. 2024).

The paradox that a certification system that is affordable to Vietnamese smallholder farmers, potentially brings the range of benefits summarised by Kaufmann et al. (2020) and Hruschka et al. (2024), and addresses an identified and increasing consumer demand, is not growing, cannot be readily explained by prior research. The inability to draw conclusions into the determinants for adoption of PGS certification in Vietnam from the results of research in other contexts indicates the need for primary research to understand the phenomenon.

Materials and methods

Theoretical framework

In any adoption analysis, capturing innovation processes and outcomes as well as selecting barriers and enablers are key considerations, which should be informed by theory (Wisdom et al., 2014). The Theory of Planned Behaviour (TPB) (Ajzen 1991) has become a widely accepted general model to predict and explain behaviour across a broad range of different contexts. A precision of the TPB in the context of technology adoption is the technology acceptance model (TAM) (Davis 1989), which essentially replaces the attitudes pillar of TPB (Bagozzi et al. 1992) and suggests that individuals will adopt new technologies if they are perceived to be both useful and easy to implement. The

collation of TPB and TAM, in the context of technology, has been named the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003). UTAUT proposes four key constructs that explain behaviour in the context of technology adoption, combining the individual with a systemic level: (1) performance expectancy, (2) effort expectancy, (3) social influence, and (4) facilitating conditions (Fig. 1).

Although UTAUT was developed to understand the adoption of technology, we consider the decision to join a PGS analogous to adopting a new technology, as both require deliberation, involve long-term commitment, and have long-term consequences. Furthermore, organic PGS participation includes numerous innovations at farm level, such as agricultural practices without the use of synthetic inputs, and beyond the farm, such as labelling and marketing. Therefore, we consider UTAUT to be an appropriate framework for understanding decisions by farmers to join an organic PGS group and adopt organic production methods.

Farmer sampling and data collection

To capture the PGS Vietnam adoption behaviour in a comprehensive way, this study relies on two complementary datasets. Both datasets were collected among vegetable farmers in the peri-urban areas around Hanoi and the two neighbouring provinces Hanam and Hoabinh (Fig. 2). PGS Vietnam is active in these three provinces and certified farmers supply vegetables to supermarkets and markets in the capital, Hanoi.

The qualitative data set includes responses from interviews with the person in charge of vegetable cultivation on 31 PGS Vietnam certified and 31 conventional vegetable farms. Lists of farmers were obtained in all villages with PGS Vietnam certified farmers from village heads and cooperatives, based on which a simple random sample of PGS Vietnam certified and non-certified farmers was drawn. Interviews were ceased once it was confirmed that saturation had been reached, meaning all relevant themes had been covered in the study (Mason 2010). The guidelines for semi-structured interviews were developed by three co-authors and based on the UTAUT framework (Fig. 1). Questions covered general trends in vegetable production in farmers' communities, perceived benefits and disadvantages of organic agriculture and PGS Vietnam certification, as well as factors that encourage and discourage PGS Vietnam adoption. Interviews took place between June and August 2022.

The quantitative dataset includes data from a farm household survey, jointly developed and tested by project

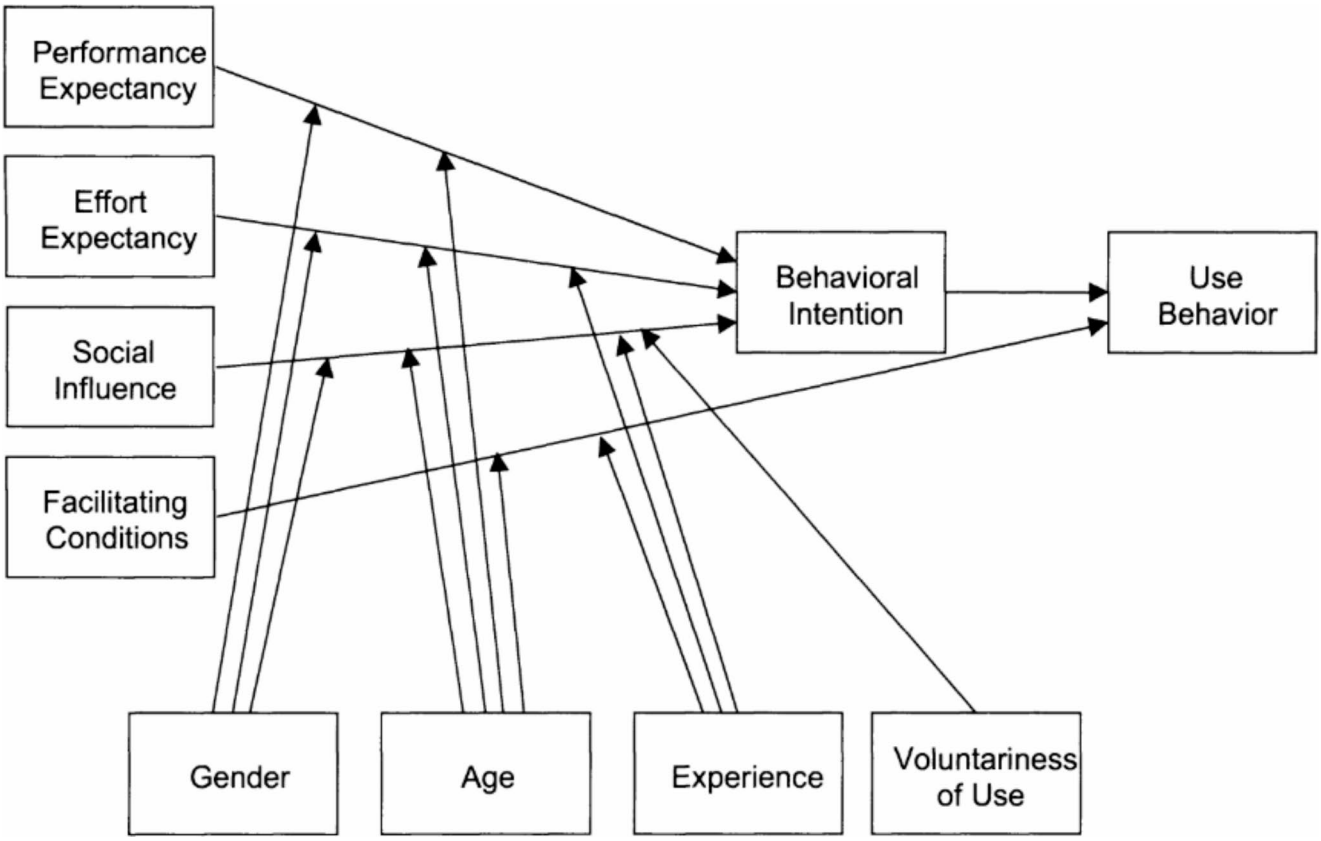

Fig. 1 Unified Theory of Acceptance and Use of Technology (UTAUT) with arrows indicating predictors (Venkatesh et al.,2003)

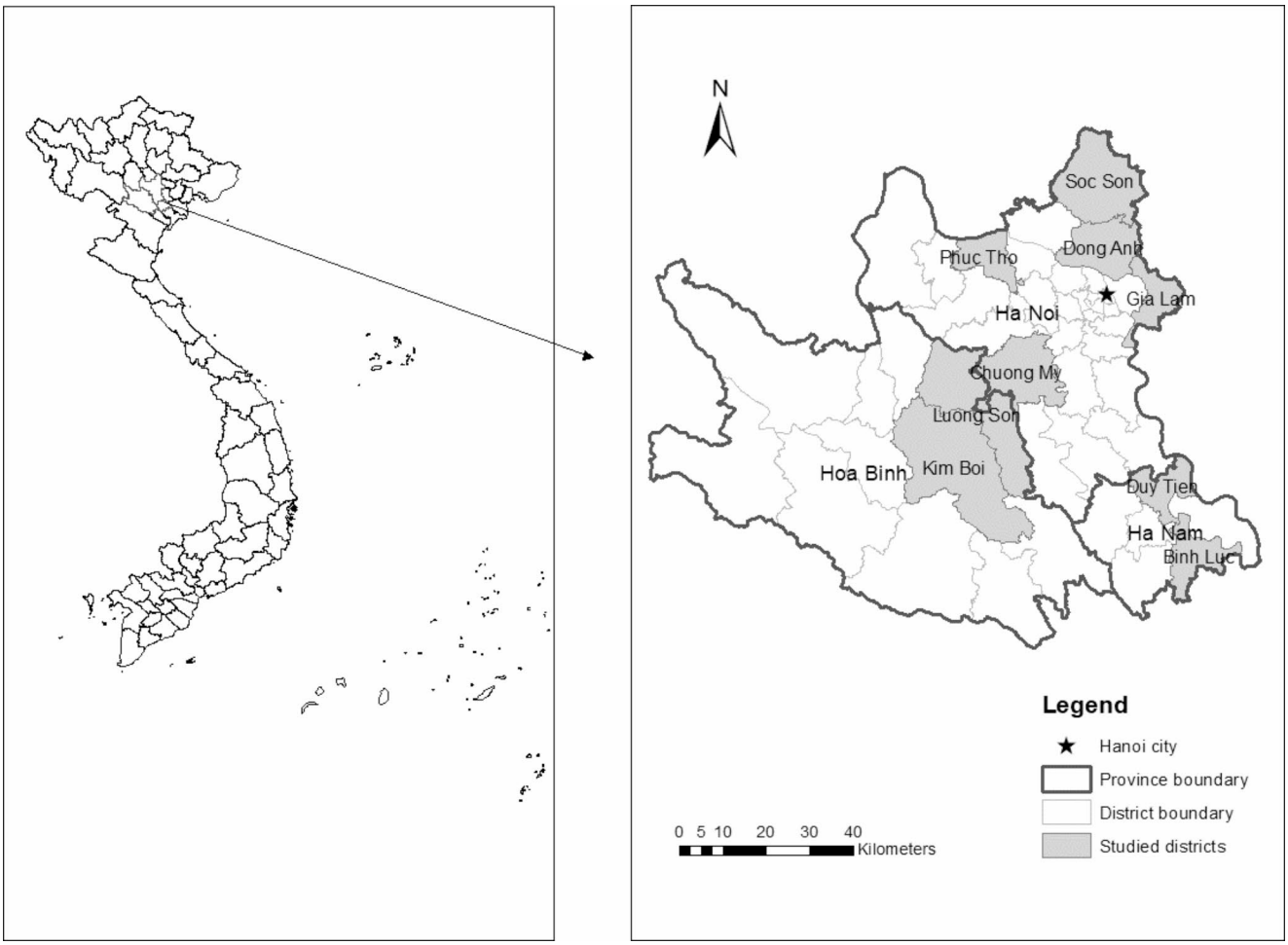

Fig. 2 Map of Vietnam (left) and the study area (right) around the capital Hanoi.
(Source: Own graph, developed using ArcMap 10.8.)

partners. The structured questionnaire, designed to estimate the causal impact of organic PGS certification on environmental, social, and economic outcomes in our study region (Grovermann et al. 2024), consisted of approximately 200 questions covering farm and farmer characteristics, farm management, networks, and past and present certifications. The survey data was collected between March and April 2023. All PGS Vietnam certified interviewees also participated in the survey, but no conventional farmer did both. The survey was administered through an interview with the main person in charge of vegetable cultivation. The selection of farms for this part of the study was based on a cluster random sampling approach, as explained in more detail in Grovermann et al. (2024): For organic PGS certified farms, all those having grown brassica in the winter season 2022/23 in the three provinces of Hoabinh, Hanam, and Hanoi were included in the sample. This sub-sample amounted to 80% of all PGS certified farms in the study area, as brassicas are the commercially most important crops for the winter season. The sample size for conventional farms was determined by power calculations, focusing on profitability as the main outcome variable. This suggested a minimum group size of 279 farms, with an additional 5% buffer for potential data loss. Power calculations were based on a one-sided two-means comparison and a fixed intervention group of 120. Sampling for conventional farms was conducted to ensure high representativeness, involving randomisation of villages with 10–14 brassica growers and surveying at least 10 farmers per village until 314 questionnaires were completed. Combining the PGS-certified and conventional farm sub-samples, the final dataset included 437 farms across 26 villages in nine districts. After excluding one observation due to missing data, the final sample comprised 436 farms.

The interview guidelines and structured questionnaire were implemented in the data collection and management software Kobo toolbox, with seven interviewers recording farmers' responses in Vietnamese on tablets. Interviewers were trained by the co-authors before data

collection. Data was exported into MS Excel and translated into English. Before each interview, interviewers provided information on the purpose and content of the interview and survey, ensured that the data provided would be handled confidentially, and gained verbal participation consent from farmers. Interview guidelines and structured survey are available from the authors on request.

Data analysis

Qualitative data analysis

We analysed the farmer interviews using a qualitative content analysis (Mayring 2014). This approach follows a systematic and rule-bound procedure and enables the structured analysis of explicit and descriptive as well as latent and interpretative content. It uses a multi-level framework of different categories by grouping statements with common characteristics (Graneheim et al. 2017). In this case, we grouped statements into enablers and disablers of PGS Vietnam certification at individual and systemic level, according to the four key constructs of UTAUT. As some information on the local context was known to the authors, we combined a deductive and inductive approach to develop the assessment framework, following a dynamic process that required regular restructuring of the framework. Transcribed interviews were coded and analysed using the software MAXQDA (www.maxqda.com). In the results section, we avoid mentioning response frequencies to prevent them from being misinterpreted as community-wide proportions, as the qualitative sample does not support this interpretation. Furthermore, we present the English translations of direct quotes from farmers in italics.

Quantitative data analysis

Descriptive statistics

For a general overview of differences between PGS Vietnam and conventional farmers, we compared key characteristics between the two groups in our survey data. We compared categorical variables using chi-squared test and continuous variables using non-parametric Wilcoxon rank sum test.

Model estimation strategy

We applied a two-stage estimation framework to account for a potential sample selection bias with a binary response variable, following Van de Ven and Van Praag (1981) and similar to the Heckman (1979) model, which, contrary to our model, is for a continuous response variables. We used the Stata 17 software package (www.stata.com) and implemented the model estimation through the *heckprobit* routine. The first-stage probit model includes factors that determine awareness of PGS certification, while the second-stage probit model identifies factors that determine PGS Vietnam adoption among the sub-sample of farmers who are aware of PGS certification. Both stages of the model are simultaneously estimated. Therefore, any bias resulting from non-exposure to the concept of PGS certification, is taken into account when estimating the adoption model:

$$y^{outcome}{}_i = (x_i\beta + u_{1i} > 0)$$

where y_i represents the binary variable of PGS Vietnam adoption by a farm i, x_i is a vector of exogenous regressors, β is a vector of parameters to be estimated, and u_{1i} is the error term. y, however, is not always observed as farmers' decision whether or not to adopt PGS Vietnam certification depends on their awareness, captured by the following selection equation:

$$y^{select}{}_i = (z_i\gamma + u_{2i} > 0)$$

where u_1~N(0,1), u_2~N(0,1), and corr u_1, $u_2 = p$. The *heckprobit* routine produces a Wald test on independent equations on the null hypothesis that $\rho = 0$. In this case, non-exposure bias would not exist and the two-stage model can be simplified into a one-stage adoption model (Keil et al. 2017).

As determinants of awareness and adoption of PGS Vietnam certification, we used a range of farmer, farm, and network characteristics (Online resource 1). These characteristics included farmers' age, education, and attitude; household size, farm size, non-farm income; membership of a farmer or women's group, and exchange frequency with neighbours. We log-transformed the skewed continuous variables, adding a small constant to prevent data loss. The first-stage probit model (awareness) requires the inclusion of at least one predictor that is not included in the second-stage probit model (adoption). We used the number of training sessions as this selection variable, following the hypothesis that training participation can increase farmers' exposure to knowledge about certification programs. Training sessions were on vegetable farming in general and not focussing on organic farming or PGS certification. We can safely assume that PGS Vietnam farmers have a sound understanding of the certification mechanism as they are actively involved in compliance monitoring and traceability requirements, as specified by the PGS Vietnam association.

Grouping farms based on attitudes.

A key factor in adoption decisions are attitudes, which can be hard to measure. Therefore, we used a set of 10 statements that aimed to reveal farmers' attitudes towards farming and the environment following Cullen et al. (2020) and

Howley et al. (2015) (Online resource 2). Farmers were asked to express their level of agreement to each statement on a 5-point Likert scale. Similar to clustering techniques, latent class analysis (LCA) is a mixture model approach that identifies "hidden groups from observed data" (Oberski 2016). This is done by assuming that observations, i.e. farmers, can be classified with varying degrees of probabilities into classes with different profiles. We carried out LCA (*gsem* command in Stata) using the Likert scale responses to 10 statements and selected the best model with the most suitable number of groups based on the Bayesian information criterion (BIC) (Schwarz 1978). This resulted in three attitude classes of farmers, which we named Productivists, Moderates, and Forward-looking caretakers, inspired by Cullen et al. (2020). Productivists prioritise farming output over environmental conservation; forward-looking caretakers are future-oriented and prioritise long-term conservation of natural resources; moderates are considered in between. The class with the highest likelihood for each farmer was used as an independent variable in the subsequent regression analysis.

Results

Descriptive results

Qualitative interviews provided insights into the production and marketing situation among PGS Vietnam certified and conventional farmers in peri-urban Hanoi. PGS Vietnam farmers in the two provinces Hanoi and Hoabinh grow vegetables individually on small plots of land within an organic management area that is surrounded by a bio-buffer zone. In comparison, vegetable cultivation is done collectively in the province of Hanam, where individual farmers record their monthly labour contribution and receive a corresponding payment. The collective marketing of produce requires some coordination between PGS Vietnam certified farmers, who receive daily vegetable orders from the retailers. In some farmer groups, group leaders serve as traders and communicate vegetable orders to each farmer, then collecting and transporting the vegetables to retailers in Hanoi. Produce that is not sold into organic vegetable value chains is offered directly by farmers at local wet markets for the same price as conventional vegetables or even used as animal feed or composted if vegetable quantities are small or prices are low.

Table 1 shows the descriptive statistics of PGS Vietnam certified and conventional farmers that were part of our quantitative survey. Despite an average age of 57 years, PGS Vietnam farmers were significantly younger than conventional farmers. PGS Vietnam farmers had significantly more female respondents, lower vegetable growing experience, larger household sizes, and grew vegetables on less land. Furthermore, PGS Vietnam certified farmers exchanged significantly more often with other farmers, participated in significantly more farmer trainings, and significantly more often belonged to a farmer group. Marketing channels also differed significantly between PGS Vietnam certified farmers, who mostly sold to shops or supermarkets, and conventional farmers, most of which sold to local collectors who pick up the produce at the farm. The distribution of the three attitude classes of farmers, *Productivists*, *Moderates*, and *Forward-looking caretakers*, was significantly different among PGS Vietnam certified and conventional farmers. *Moderates* represented the largest group with 51% of our sample. Among PGS Vietnam certified farmers, *Productivists* were the smallest group with 6.5% of this sub-sample.

Perceived developments in vegetable farming around Hanoi

Results from the farmer interviews showed that both PGS Vietnam certified and conventional farmers have a mixed perception of the development of vegetable farming in and around Hanoi. They reported that vegetable yields have generally increased due to better technical skills among farmers and access to higher yielding varieties. Conventional farmers also perceived that declining soil fertility threatens vegetable farming. PGS Vietnam certified and conventional farmers noted changes in weather patterns that make vegetable farming more challenging. Farmers agreed that the decline in vegetable farmers and production area is mainly due to a lack of successors, youths viewing agriculture as hard and low-income, and a general labour shortage. On this, one farmer mentioned: "*[I] previously planted more varieties. Currently, a part of the land has been converted to guava to reduce labour, as growing vegetables takes more work*" (PGS farmer).

Based on conventional farmers' observations, the amount of synthetic pesticides and mineral fertilisers used by conventional farmers in their communities is declining, generating noticeable health improvements. This change is due to diverse reasons, including greater awareness and public pressure. Farmers expressed this by statements like: "*[The use of pesticides and fertilisers is] now limited because of public condemnation; farmers' awareness of food safety and hygiene has increased*" (conventional farmer). "*Farmers are more conscious in protecting the environment as well as protecting their own health. In the past, people had to wear boots to go to work with fear of itching, now they often go barefoot to work in the fields*" (conventional farmer).

Table 1 Mean (sd) for continuous variables and n (%) for categorical farmer, farm, and network characteristics variables among PGS Vietnam certified and conventional farms

	PGS Vietnam ($n=123$)	Conventional ($n=313$)	Total ($n=436$)	p-value
Male respondent (yes)	18 (14.6%)	84 (26.8%)	102 (23.4%)	0.007
Male household head (yes)	90 (73.2%)	236 (75.4%)	326 (74.8%)	0.630
Age of respondent (years)	56 (9.0)	58 (8.7)	57 (9.0)	0.028
Education of respondent (years)	7.8 (2.0)	7.5 (2.2)	7.6 (2.2)	0.128
Vegetable growing experience of respondent (years)	14.8 (8.5)	27.7 (12.5)	24.0 (12.9)	< 0.001
Attitude class				< 0.001
Moderates	83 (67.5%)	140 (44.7%)	223 (51.1%)	
Forward looking caretakers	32 (26.0%)	33 (10.5%)	65 (14.9%)	
Productivists	8 (6.5%)	140 (44.7%)	148 (33.9%)	
Awareness PGS (yes)	123 (100.0%)	60 (19.2%)	183 (42.0%)	< 0.001
Household size (members)	4.7 (1.8)	4.3 (2.1)	4.4 (2.0)	0.039
Household members contributing to vegetable cultivation (members)	1.8 (0.8)	1.8 (0.7)	1.8 (0.7)	0.694
Size of vegetable plots (1000 m^2)	1.18 (1.36)	1.51 (1.35)	1.42 (1.36)	< 0.001
Secure land title (share of vegetable plot)	0.80 (0.37)	0.79 (0.32)	0.79 (0.33)	0.115
Non-agricultural income (Million VND)				0.066
0–10	11 (8.9%)	60 (19.2%)	71 (16.3%)	
10–50	19 (15.4%)	50 (16.0%)	69 (15.8%)	
50–100	31 (25.2%)	69 (22.0%)	100 (22.0%)	
> 100	62 (50.4%)	134 (42.8%)	196 (45.0%)	
Diversity non-farm activities (number)	1.3 (0.5)	1.1 (0.4)	1.2 (0.4)	< 0.001
Main marketing channel				< 0.001
Local collector	28 (22.8%)	170 (54.3%)	198 (45.4%)	
Local market	6 (4.9%)	131 (41.9%)	137 (31.4%)	
Shop / supermarket	47 (38.2%)	2 (0.6%)	49 (11.2%)	
Cooperative	37 (30.1%)	3 (1.0%)	40 (9.2%)	
Average brassica price (1000 VND/kg)	14.5 (2.5)	6.04 (3.0)	8.44 (4.78)	< 0.001
Loan in past 3 years (yes)	15 (12.2%)	41 (13.1%)	56 (12.8%)	0.800
Province				< 0.001
Hanam	4 (3.3%)	55 (17.6%)	59 (13.5%)	
Hanoi	51 (41.5%)	245 (78.3%)	296 (67.9%)	
Hoabinh	68 (55.3%)	13 (4.2%)	81 (18.6%)	
Distance to Hanoi city centre (km)	35.5 (6.0)	37.5 (17.8)	36.0 (15.4)	0.064
Exchange frequency with other farmers				< 0.001
Rarely	12 (9.8%)	48 (15.3%)	60 (13.8%)	
Sometimes	10 (8.1%)	90 (28.8%)	100 (22.9%)	
Often	101 (82.1%)	175 (55.9%)	276 (63.3%)	
Training participation in past 10 years (number of courses)	14.3 (10.0)	6.6 (8.1)	8.8 (9.3)	< 0.001
Extension visits in past 5 years (number of visits)	0.37 (1.59)	0.19 (0.97)	0.24 (1.18)	0.168
Neighbours with same certification (yes)	105 (85.4%)	41 (13.1%)	146 (33.5%)	< 0.001
Member of cooperative (yes)	67 (54.5%)	108 (34.5%)	175 (40.1%)	< 0.001
Member of farmer group (yes)	71 (57.7%)	49 (15.7%)	120 (27.5%)	< 0.001
Member of women's group[1] (yes)	72 (68.6%)	155 (67.7%)	227 (68.0%)	0.872
Past certification under any scheme (yes)	2 (1.6%)	17 (5.4%)	19 (4.4%)	0.080

Continuous variables were compared using Wilcoxon Rank Sum test and categorical variables using Chi-square test; [1]Refers to the share of female respondents

Factors encouraging and discouraging adoption of PGS Vietnam certification

The results are presented according to the four key constructs that explain behaviour in the context of technology adoption based on the UTAUT (Fig. 3). The UTAUT model was useful for the division of factors that encourage or discourage the adoption of PGS Vietnam certification, but individual factors can be interrelated and mutually dependent. This section presents combined results of the content

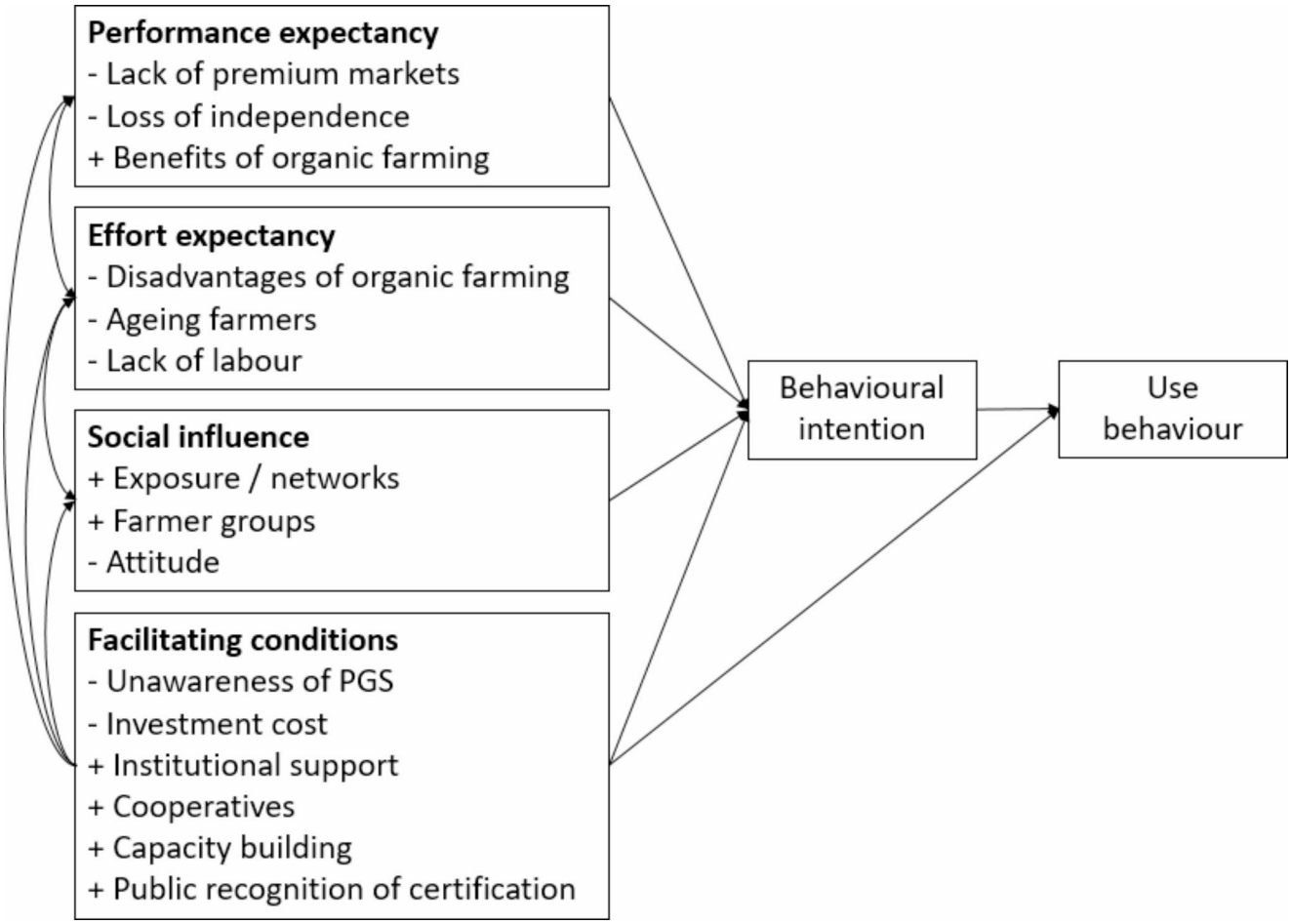

Fig. 3 Factors acting as enablers (+) and disablers (−) of PGS Vietnam adoption among Vietnamese vegetable farmers, using the Unified Theory of Acceptance and Use of Technology (UTAUT) where arrows indicate predictors (Venkatesh et al., 2003)

analysis of farmer interviews with the results from the sample selection model, conditional on farmers' awareness of PGS certification, using our survey data (Table 2).

Performance expectancy

This describes farmers' outcome expectation and the perceived usefulness of PGS certification based on extrinsic motivation (Venkatesh et al.,2003).

The lack of demand through marketing channels for organic vegetables that compensate farmers for the perceived disadvantages of organic agriculture was mentioned as one of the most important discouraging factors for PGS Vietnam adoption. It reduces farmers' performance expectancy of PGS Vietnam certification. They expressed this through statements like: "*There is no output market. Selling at the local market is low price*, *not commensurate with my work and investment costs*" (conventional farmer). Local vendors and markets were still the main marketing channel of respectively 23% and 5% of PGS Vietnam farmers in our sample, compared to 54% and 42% of conventional farmers, respectively (Table 1). Furthermore, the supply of organic vegetables is perceived to not match its demand in Hanoi, as stated by this farmer: "*There is still a surplus of goods that cannot be sold*, *so they have to sell to the local market at a low price compared to regular vegetables*" (PGS farmer). The insufficient demand from premium markets was furthermore mentioned as a factor for leaving PGS Vietnam, conveyed by a statements like: "*I used to grow organic vegetables*, *but now there is no consumer market*, *so I don't do it anymore*" (conventional farmer). However, major challenges for a smooth marketing of organic vegetables also exist at the group level, as reported in this statement: "*For two months now*, *the director [of the group] has not paid the people for vegetables yet*, *so many people quit [working on their farm or return to conventional farming]*" (PGS farmer).

Farmers reported a loss of independence. Particularly, the need to organise with other farmers and comply with the rules of organic farming and certification, thus the loss of independence, were perceived as barriers to PGS Vietnam adoption. This is exemplified by these two statements: "*I*

Table 2 Results of the sample selection model. Maximum likelihood estimates of Heckman probit selection model explaining awareness of PGS certification (1st stage) and adoption of PGS Vietnam certification conditional on awareness (2nd stage)

	Awareness	Adoption cond. on awareness
Male person in charge of vegetable cultivation (yes)	0.21 (0.191)	-0.58 (0.459)
Education of respondent (years)	0.06 (0.036)	-0.45*** (0.131)
Age of respondent (years)	0.01 (0.009)	0.01 (0.033)
Vegetable growing experience of respondent (years)	-0.03*** (0.008)	-0.03 (0.023)
Attitude of respondent (reference: Moderates)		
Productivists (yes)	0.00 (0.185)	-1.77*** (0.615)
Forward looking caretakers (yes)	0.08 (0.234)	0.51 (0.455)
Household size (members)	-0.08* (0.042)	0.43*** (0.117)
Vegetable plot size (ln(m^2))	0 (0.067)	-1.14** (0.482)
Vegetable plot with title (share of vegetable plot)	0.23 (0.231)	-0.55 (0.445)
Diversity non-farm income (number of different income sources)	0.12 (0.189)	0.4 (0.430)
Loan in last 3 years (yes)	-0.16 (0.228)	0.35 (0.532)
Distance Hanoi (km)	-0.02* (0.009)	-0.05* (0.026)
Neighbours have same certification (yes)	1.05*** (0.197)	1.00* (0.522)
High exchange frequency with other farmers (yes)	0.41** (0.165)	0.82 (0.536)
Extension visit in past 5 years (number of visits)	-0.05 (0.058)	0.07 (0.197)
Member of farmer group (yes)	0.46** (0.184)	1.29*** (0.450)
Member of women's group (yes)	0.34** (0.156)	1.41*** (0.495)
Province (reference: Hanoi)		
Hanam (yes)	0.58 (0.417)	1.87 (1.328)
Hoabinh (yes)	1.15*** (0.252)	4.17*** (1.079)
Training participation in past 10 years (number of courses)	0.03*** (0.010)	
Intercept	-1.36 (0.875)	9.75** (4.519)
Wald test of independent equations	rho = 0 chi2(1) = 4209.53 prob. > chi2 = 0.000	
N (1st stage)		436
N (2nd stage)		183

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; Robust standard errors

want to grow freely, *with no restrictions on fertilisers*" (conventional farmer). "*[I have] increased autonomy […] due to self-determination of production*" (conventional farmer). As such, the share of land owned by farmers for vegetable cultivation showed a significant and negative relationship with PGS Vietnam adoption (Table 2), as PGS Vietnam farmers rather rent or share land.

Farmers mentioned numerous benefits of organic vegetable cultivation. PGS Vietnam certified and conventional farmers perceived organic farming to be more profitable, requiring lower input costs, providing stable yields and prices, having less impact on human and environmental health, offering safer food, and improving soil fertility. This increases farmers' perceived performance of organic farming. In fact, PGS Vietnam farmers reported average vegetable prices per kilogram more than twice those of conventional farmers (Table 1). The benefits are exemplified by these farmers' comments: "*The land has been organically farmed for many years*, *the quality of the soil is enhanced*, *so it doesn't [need] a lot of investment*" (PGS farmer). "*Since growing organic vegetables*, *I have been healthier because I don't use harmful chemicals*" (PGS farmer).

Effort expectancy

Effort expectancy describes the degree of ease and the complexity associated with the use of the technology (Venkatesh et al., 2003).

In addition to perceived benefits of organic farming, farmers also reported several important **disadvantages** that **organic vegetable farming** brings. Conventional farmers mentioned that organic farming requires higher labour investments and costs as well as has strict production rules. PGS Vietnam certified farmers additionally mentioned lower yields and the unavailability of efficient pest control inputs, leading to higher pest pressure. They additionally perceive organic farming as more difficult and knowledge-intensive, as expressed this by a statement like: "*Everyone knows the benefits of growing organic vegetables*, *but people don't do it because it's difficult to make organic vegetables*" (PGS farmer).

At farm level, farmers' **advanced age** and reduced physical strength was mentioned as a barrier to organic farming that increases farmers' efforts. These two statements express this notion: "*My husband and I are both old and do not have*

the health enough to produce organic vegetables" (conventional farmer); "*Only middle-aged farmers grow organic vegetables*" (conventional farmer). Our survey data confirm this trend (Table 1), as farmers' average age was 57 years, and certified farmers were significantly younger. However, farmer age was not negatively associated with PGS Vietnam adoption in our survey data (Table 2). Several conventional farmers now care for their grandchildren while their children work non-agricultural jobs, leaving little or no time for farming. The worker shortage raises childcare costs, which some farmers cannot afford, forcing them to quit.

In addition to the advanced age of individual farmers, the **lack of available workforce** in rural areas and the lack of farm successors was mentioned as a negative contributing factor to effort expectancy. Farmers reported that farming is still a sector to leave behind if off-farm opportunities arise, as expressed by this statement: "*Young people go to work as workers because producing vegetables is hard work and their income is lower*" (conventional farmer). This is also influenced by the lack of markets for organic vegetables that pay price premiums. Household size, a proxy for household labour availability, showed a significant and positive relationship with PGS Vietnam adoption in our survey data (Table 2).

Social influence

This describes in how far PGS Vietnam adoption is influenced by subjective norms and social factors, thus enhances farmers' image and status (Venkatesh et al., 2003).

Farmer network and exposure to certification schemes emerged as an important enabling factor for PGS Vietnam adoption. The factor that neighbouring farmers have the same certification was significantly and positively associated with both PGS Vietnam awareness and adoption (Table 2), demonstrating a neighbourhood effect. Farmers' responses in the interviews also show a farmer-to-farmer exchange, as stated by this farmer: "*At first*, *the household didn't want to grow organic PGS vegetables because it took a lot of time*, *but encouraged by previous growers*, *they agreed to grow it and felt good about their income and not having to use drugs*" (PGS farmer). In our survey data, PGS Vietnam certified farmers exchanged significantly more often with other farmers than conventional farmers (Table 1) and a high exchange frequency with other farmers was significantly and positively associated with being aware of PGS certification (Table 2).

Furthermore, **farmers' attitude** is an important factor against PGS Vietnam adoption. Our sample selection model shows no relationship between attitude and awareness, but a significant and negative relationship between the attitude class *Productivist* and PGS Vietnam adoption compared to *Moderates* (Table 2). Additionally, farmers' attitude towards farming in general might enable PGS Vietnam adoption, as shown by this statement: "*Only those who love the job can survive*, *many people find [organic farming] difficult*" (PGS farmer). Farmers' attitude can also influence the benefits they perceive from organic agriculture, influencing their performance expectancy and thus encouraging or discouraging PGS Vietnam certification.

Facilitating conditions

Facilitating conditions refer to the availability of organisational and technical infrastructure and the compatibility of technology with farmers' values and needs (Venkatesh et al., 2003).

Our survey data show that 58% of farmers in our quantitative sample were **not aware of PGS certification**. Some farmers first heard of 'organic' during the interview, as this farmer stated: "*I just only learned about safe vegetables*, *haven't learned about organic vegetables yet*" (conventional farmer). In addition, unawareness of the underlying problems for environmental and human health might contribute to this disabler, as expressed by this statement: "*I think the land and the water is not polluted*" (conventional farmer).

Additionally, conventional farmers perceived the **investment costs** for PGS Vietnam certification to be high, influencing their effort expectancy. This is especially the case for required technological changes, such as irrigation systems: "*Because of the need to invest in more technology*, *we cannot use normal water like now*" (conventional farmer).

Both certified and conventional farmers mentioned **support by institutions** as an important facilitating condition for PGS Vietnam adoption, including with certification organisation, initial investments, machinery, inputs, trainings, infrastructure, and market access. Many PGS Vietnam farmers mentioned the initial support with certification by the NGO ADDA. Conventional farmers mentioned their willingness to consider adoption if there was more support, as expressed by this statement: "*If there is a programme to teach organic vegetables*, *someone to guide the people*, *to invest*, *I would do it*" (conventional farmer).

Participation in a **cooperative** or **group** was perceived as beneficial for certified farmers, as they organised the PGS Vietnam certification and marketing of goods. As one farmer highlighted, "*People participating in the cooperative do not have to pay for the certificate*, *the certification procedure is not difficult because the cooperative takes care of it*" (PGS farmer). Farmers' participation in a farmer or women's group was positively and significantly related to awareness and adoption of PGS Vietnam certification (Table 2). Cooperatives and groups additionally offered **capacity building** opportunities for farmers, exposing farmers to alternative

production practices. Our sample selection model showed a significant and positive relationship of training participation with awareness of PGS Vietnam (Table 2).

Finally, the **public** and legal **recognition** and promotion of PGS Vietnam through local governments enabled its adoption, for example through specific land use planning that allocate organic production areas with buffer zones and specific irrigation systems to avoid contamination from conventional production. Farmers expressed this by a statement like: "*[The government] supported consolidation and exchange of plots for convenient organic production*" (PGS farmer).

Discussion

In addressing the aim of identifying the factors that encourage or discourage PGS Vietnam certification among Vietnamese vegetable farmers, we uncovered both systemic conditions and individual-level factors that facilitate and hinder PGS Vietnam certification (Fig. 3). These factors are partly interacting and mutually reinforcing.

The **performance expectancy** of PGS Vietnam was mainly influenced by the lack of markets with premium prices that buy all organic vegetables produced; despite a reported growing demand for organic products for domestic and export markets in Vietnam (Anselmi & Moura e Castro, 2023). Despite this perceived disadvantage, organic farming can be economically viable in peri-urban Hanoi: Phamova et al. (2022) and Grovermann et al. (2024) reported higher farm income and profitability among organic and PGS certified farmers compared to conventional farmers in our study region, in spite of lower yields among organic farmers. The significantly higher organic prices in our study suggest the potential to offset lower yields and higher labour inputs if all produce is sold at organic premiums. And farmers in this study did expect price premiums. This result contrasts the conclusions of Enthoven and Van den Broeck (2021, 2023) and Holzapfel and Wollni (2014) that vegetable farmers around Hanoi were willing to produce *safe* vegetables without price premiums under the condition of stable and long-lasting contracts with buyers. The limited willingness to pay extra for pesticide-free vegetables among Vietnamese consumers may be due to a low familiarity with food certification (My et al. 2017), or different perceptions of safe and/or organic vegetables between consumers and producers (Enthoven and Van den Broeck 2023; My et al. 2017). Direct relationships with PGS producers and farm visits are an important source of trust among consumers (Kaufmann et al. 2023a; Rodrigues Hirata et al. 2021), potentially influencing their willingness to pay.

Labour availability represents an issue in our study area and mainly influenced farmers' **effort expectancy**: High average ages combined with low physical strength and little available labour due to competition with more lucrative jobs outside agriculture were mentioned repeatedly as an important factor for increased effort expectancy of organic vegetable farming. This confirms the local effects of wider demographic trends in Vietnam, with a decreasing share of the population employed in agriculture (65% in 2000 and 29% in 2021 (The World Bank 2023a) and an increase in urban population (24% in 2000 and 38% in 2021 (The World Bank 2023b). Additionally, time investments in PGS can be substantial (Kaufmann et al. 2023a), contributing to farmers' workload. Collective land management, as is done in Hanam province, has been shown to reduce production cost as well as labour investments while improving produce quality in the same region (Whitney et al. 2014), thus representing a potential solution. But it also requires more coordination between farmers; and losing independence demotivated sampled farmers to join PGS Vietnam. The incorporation of fruit trees alongside vegetables, as done on some sampled farms, could furthermore save labour. Similar strategies have been noted in neighbouring countries, such as Cambodia (Kong et al. 2021).

Our study confirmed the importance of **social influence** in the adoption of voluntary certification, such as participating in farmer groups and a regular exchange farmer-to-farmer exchange. Social pressure might be an even stronger driver for PGS adoption in northern Vietnam than in other regions or countries, as this area has a strong collectivist social organisation (Ho et al. 2022). Our results are in line with Phamova et al. (2022), who showed that organic farmers cooperated more with other farmers than both conventional and VietGAP farmers in northern Vietnam. Social pressure was also shown to influence Vietnamese coffee farmers' adoption of sustainable agricultural practices (Nguyen and Drakou 2021). Social interactions and exchange of knowledge in certification schemes can be an important incentive for farmers to join (Rizal and Nordin 2022), and have been reported the central benefit of PGS participation in Chile (Hruschka et al. 2022). Farm inspections in PGS can be important for exchange of knowledge and experiences (Kaufmann et al. 2023a). Neighbours' certification in our sample was positively associated with PGS Vietnam adoption, confirming the results by Wollni and Andersson (2014) among organic farmers in Honduras.

Women in northern Vietnam are often the main decision-makers for vegetable cultivation and marketing (Enthoven and Van den Broeck 2021). Voluntary certification was shown to reduce gender inequality among smallholder farmers (Meemken and Qaim 2018), but Vietnamese women in agriculture still face numerous disadvantages compared

to men, such as lower access to resources (land, labour, finance, technology, training, and markets) and agricultural extension services (Catacutan and Naz 2015; FAO 2019). This potentially puts them at a disadvantage in overcoming the adoption hurdles for voluntary certification, such as bureaucratic and cost barriers (Nelson et al. 2016). The positive relationship between women's group membership and PGS Vietnam awareness and adoption in our results supports the notion that PGS certification can be more gender inclusive and thus reduce gender inequalities in value chains, as proposed by past research (Home et al. 2017). These results, however, contradict a long history of disempowerment of women in agriculture (Tavenner and Crane 2022) so should be considered cautiously and taken in context. Vernooy et al. (2022) use the example of farmer seed systems, in which women farmers are often as the principal seed custodians and which Home et al. (2017) propose as evidence of empowerment in PGS initiatives, to imply that positions of power held by disadvantaged groups can become attractive targets for their oppressors. The finding in this study that PGS certification can contribute to reducing gender inequalities can therefore also be interpreted as a warning that the gains in gender equality and empowerment might erode over time. Vernooy et al. (2022) point out that the position of women in key roles in agriculture, such as farmer seed systems, "are often overlooked by researchers, development personnel, policies, and programs", so it will be the challenge of future research to explore these power dynamics further and to develop strategies to maintain gender equality gains in PGS initiatives.

Our results showed a large number of **facilitating conditions** that encouraged and discouraged PGS Vietnam adoption. Our quantitative analysis showed the importance of social networks and groups for PGS awareness and adoption, thus in line with past literature (Liu et al. 2018). Additionally, support from diverse stakeholders as well as the public and legal recognition of PGS Vietnam, combined with the designation of organic management areas, facilitated its development. Legal recognition has been identified as a crucial factor contributing to the success of PGS (Montefrio and Johnson 2019), despite potentially increasing required administrative procedures (Hruschka et al. 2022). Furthermore, PGS Vietnam was initially supported by the Danish NGO ADDA. While this is common for PGS globally and might accelerate the initial adoption process, it also reduces farmer participation in their design and ownership (Cuéllar-Padilla et al. 2022; Home et al. 2017). The declining numbers of certified farmers around Hanoi might be an indication of the low sustainability of this set-up.

Methodological discussion and limitations

The Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003) proved a suitable framework for our analysis. While previous research predominantly employed UTAUT in quantitative analyses, such as structural equation modelling (Williams et al. 2015), we demonstrated its applicability in qualitative and mixed-method research approaches. This approach enabled to better capture some of the system complexity in a qualitative way, while quantitatively zooming in into specific associations. With the qualitative data, we were able to find out about more general, systemic factors that influence farmers' decision to adopt PGS Vietnam. These would not have displayed sufficient variance in our data set to include them in the adoption model, given that all farmers are part of the same system. The quantitative data, on the other hand, allowed for generalisation due to the larger sample size. This approach generally increased the explanatory power of the UTAUT framework within our study context.

We opted for a Heckman model to quantitatively assess PGS Vietnam adoption, primarily because it addresses exposure bias, although at the expense of estimating causal relationships. This approach differs from previous studies, employing structural equation models (e.g. Issa and Hamm 2017) or not controlling for awareness in adoption studies (e.g. Krause et al. 2016). Our results underline the importance of accounting for farmers' unawareness of agri-environmental schemes, such as PGS, in future research.

Our understanding of why smallholder farmers adopt organic PGS certification is not complete. In our study design has some limitations that warrant a cautious interpretation of the results. First, our quantitative approach was limited to the indicators included in the farmer survey. Thus, we could not control for some potentially important indicators, such as contract farming that is common in the region (Enthoven and Van den Broeck 2021) and a potential enabler of certification adoption in horticulture (Chelang'a et al. 2023). Moreover, many farmers in our study areas had abandoned PGS Vietnam certification and could not be reached to participate in this study. It will be the challenge of future research to reach this group and investigate the factors and pathways that were responsible for the decision to leave PGS. Second, we include only brassica farmers in our quantitative sampling approach. Future research should investigate PGS adoption in different, less labour-intensive farming systems to corroborate our results.

Conclusions and recommendations

Despite substantial policy interventions in Vietnam to reduce synthetic pesticide use in vegetable cultivation and improve food safety, vegetable farming in peri-urban Hanoi remains heavily reliant on inputs, and food safety concerns persist. In this study, we investigated factors that encourage and discourage PGS Vietnam adoption in the three Vietnamese provinces Hanoi, Hanam, and Hoabinh. We present results from a mixed methods approach, integrating the qualitative analysis of farmer interviews with the quantitative analysis of a farmer survey using the Unified Theory of Acceptance and Use of Technology. Overall, we find that various factors reduce farmers' expected performance and increase their expected effort, thereby discouraging the adoption of PGS Vietnam. Social factors and systemic facilitating conditions, on the contrary, proved to be powerful pathways for motivating PGS Vietnam adoption. Individual and systemic factors are partly interacting and mutually reinforcing.

We summarise our recommendations in three points, addressing major challenges for PGS Vietnam adoption identified in this study. These can be helpful for future private and public interventions promoting PGS Vietnam in peri-urban Hanoi and organic PGS in similar settings across low- and middle-income countries.

Lack of awareness Despite prolonged advocacy, few vegetable farmers in the case study region were aware of PGS certification. Mainstreaming PGS information through agricultural extension services and governmental organisations could help accelerate farmers' awareness and adoption of (organic) PGS certification. Nonetheless, achieving this would require additional institutionalisation of PGS Vietnam and increased public investments. Our data additionally underscores the necessity to extend advocacy efforts beyond information inputs for farmers and consumers from external stakeholders. Additional investments need to go into strengthening farmers' social networks. Our results thus endorse calls for supporting farmer organisations, such as cooperatives, to promote safe and/or organic vegetable production (Asian Development Bank 2023; Naziri et al. 2014).

Lack of labour Labour shortage on farms, due to an aging farmer population and limited available workers, is expected to persist and possibly worsen. It is necessary to develop solutions for labour shortages and adapt current vegetable farming with labour-saving techniques, such as low-cost, low-tech mechanization for labour-intensive weeding and harvesting. One such example is substituting direct seeding with vegetable seedlings, a practice not yet prevalent in the study area. Seedlings face lower weed competition and require less manual weeding throughout the growth cycle. This offers great potential for reducing labour requirements, as weed management is considered among the most labour-intensive practices in vegetable cultivation (Whitney et al. 2014). However, a market for pesticide-free seedlings needs to be established. Labour-saving techniques could be promoted through existing training and dissemination structures. Furthermore, the attractiveness of farming for youth needs to be increased. This could be fostered by providing assistance for the adoption of agricultural technologies and innovative farming systems, which are more accessible for young people but also enhance the appeal of agriculture by offering higher, more reliable, and long-term income opportunities.

Lack of stable markets Generating stable markets with price premiums for organic produce can generally go through individual or institutional customers. The vegetable value chains around Hanoi are short, with distances of up to 75 km in our sample. This provides a suitable setting for increasing producer-consumer networks, which currently does not take place among the sampled PGS Vietnam farmers. Connections between producers and consumers can also be generated through other pathways, such as weekly organic farmers' markets in Hanoi or vegetable delivery to individual households. Public procurement has additionally been found a suitable tool to increase the demand for organic food, aligning with public objectives (UNFSS 2020). Using organic vegetables in public canteens and school kitchens fosters sector development by providing stable markets. This would require good coordination between value chain actors, a factor often hindering the growth of PGS (Enthoven and Van den Broeck 2023). Such procurement initiatives could increase awareness of food safety among various stakeholders, which was identified as a key leverage point for systemic interventions for safe vegetables in Vietnam (Ha et al. 2015). Market development requires a substantial volume and diversity of organic vegetables to be viable for traders and shops to collect the vegetables and pay premium prices. The small scales of individual vegetable farms underscores the importance of collective action and organisation to successfully establish trade partnerships.

Improving human and environmental health by reducing pesticide use in vegetable farming systems in Vietnam and beyond requires a comprehensive approach, addressing challenges from the farm through the entire value chain and even considering the future. Achieving this complex task

demands commitment, coordination, and investment from both private and public actors.

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Data availability Data and Stata code are available here: https://figshare.com/s/7d442b010e9f1ed7c985.

Declarations

Ethical approval The studies involving human participants were reviewed and approved by the Ethics committee of the Department of Food Systems Sciences, Research Institute of Organic Agriculture (FiBL) (Approval number FSS-2023-007).

Informed consent was obtained from all individual participants included in the study.

Competing interests The authors have no relevant financial or non-financial interests to disclose.

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