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Farmers intention to adopt sustainable agriculture hinges on climate awareness: The case of Vietnamese coffee

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ABSTRACT

Adoption of sustainable agricultural practices (SAP) is essential for economic, social and environmental adaptation to climate change. For cash crops like Vietnamese coffee, this is even more relevant, since the country experiences climate change impacts, with direct implications for the well-being of smallholder farmers. Understanding the factors that influence farmers' decision to adopt SAP can unravel useful recommendations for decision-makers. In this paper we explore the factors that influence farmers' intention to adopt SAP for coffee farming using data from 93 interviews in Ban Me Thuot, Vietnam. The decomposed Theory of Planned Behavior was the theoretical framing of our work, with the extension that included climate change perception and farmers' past behavior. We employed the grounded theory approach for data collection and structuring to reveal variables pertaining to sustainable agriculture adoption. We used Structural equation modeling to test the relations among behavioral determinants (attitude, social norms, perceived behavioral control, and past behavior) that lead to intention to adopt sustainable agriculture. The results showed that farmers' intention to adopt sustainable agricultural practices is influenced by their perception of social pressure and their abilities to perform sustainable agriculture. Farmers' climate change perception also significantly influenced their behavioral determinants. A significant finding was that social trust covaries with financial control. We highlight the need for raising climate perception and awareness to promote the adoption of sustainable agricultural practices while building trust in both the scientific information received by local farmers but also their social circle.

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1. Introduction

Climate change and extreme climatic events are projected to impact agriculture and food security, by reducing food availability, stability, and lowering utilization and access (IPCC, 2014). Crop yields decline due to changing climatic conditions, altering water and temperature levels has direct implications for societal well-being, requiring urgent adoption of adaptation mechanisms (Zamasiya et al., 2017). Smallholder farmers (farm area <2 ha) are among the most vulnerable toward climate change, since their farms are mostly located in regions directly affected by climate change, in low and lower middle income countries (Cohn et al., 2017). Smallholder farming, taking up 85% of all farmlands globally, is responsible for more than half of global food calorie consumed (Samberg et al., 2016). Under globalized agricultural demand facilitated by trade, smallholder farming is a typical example of a "telecoupled" system, in which interactions among distant human-environmental systems occur (Liu et al., 2013). Telecoupled systems include a "sending", "receiving", and "spill-over" system, as well as their environmental and socioeconomic components of "causes", "effects", and "agents". Hence, any climate adaptation mechanism adopted by farmers at the point of supply, (sending system), has an impact on the "receiving system" at the point of consumption.

The Food and Agricultural Organization (FAO) defines sustainable agriculture as a system that: "improves efficiency in resource use; conserves, protects and enhances natural ecosystems; sustains rural livelihoods and social well-being; enhances the resilience of people, communities and ecosystems; and promotes good governance" (Caffaro et al., 2019; FAO, 2016). A few examples of sustainable agriculture include "approaches that involve changing one component" (e.g., integrated pest management, compost and

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manure usage), reducing or integration with other systems (integrating livestock with crops, intercropping), "or a more systemic change" (organic farming, and agroecology) (Knickel et al., 2017; Šūmane et al., 2018). Sustainable agricultural practices can "improve biodiversity, reduce harmful inputs into the environment", while "maintaining competitiveness and economic viability" (Zeweld et al., 2017) by e.g., improving food security in Africa (FAO, 2014), reducing environmental pressure in coffee plantations in Vietnam (Ho et al., 2018). Sustainable agriculture plays a vital role in adaptation to climate change, as well as achieving the Sustainable Development Goals (FAO, 2016; Zeweld et al., 2017). However, despite sustainable agriculture's documented effectiveness in climate change adaptation, sustainable agricultural adoption has not been high (Zeweld et al., 2017). Reported barriers of adoption, range from farmers' perception level (FAO, 2014) to institutional level support (Bravo-Monroy et al., 2016). While sustainable agriculture has policy backing at national and regional levels in Europe (Massey et al., 2014) and the U.S. (Mase et al., 2017), such support is lacking in low-income countries e.g., in Eastern and Southern Africa (Kassie et al., 2015). Without institutional support, the adoption of sustainable agricultural techniques such as climate change adaptation mechanism is at the discretion of local farmers in low-income countries.

Farmers' responses to climate change, and adoption of sustainable practices, have been studied extensively, with most research focusing on socioeconomic factors (Caffaro and Cavallo, 2019; Pampuro et al., 2018), institutional and policy factors or resources related management (Prokopy et al., 2008). Few studies explored cognitive or psychological drivers (Zeweld et al., 2017), highlighting the role of such drivers in guiding farmers' decisions to adopt sustainable agricultural practices. Martinovska Stojcheska et al. (2016) investigated rural development support application in Bosnia, Herzegovina, and (North) Macedonia and found that while cognitive drivers matter, socioeconomic factors have no impact on farmers' intentions. Zeweld et al. (2017) also state that economic resources and facilities are necessary but not sufficient, suggesting the importance of socio-psychological factors in promoting sustainable practices.

Several socio-psychological frameworks have been used to address behavior change for the assessment and consideration of socio-psychological factors that lead to the adoption of "new behavior" (Schlüter et al., 2017). These range from economics-based theories in which societal groups make rational decisions, (e.g., theories of Rational Actor, Bounded Rationality, Expected Utility), to psychological ones, in which societal groups evaluate decisions based on their intention, social norms or the combination of both (e.g., Theory of Planned Behavior, Descriptive Norms and Habitual Learning) (Schlüter et al., 2017). Of the many socio-psychological frameworks, the most popular theory in assessing intention to adopt pro-environmental behavior is the Theory of Planned Behavior – TPB (Klöckner, 2013). TPB posits that intention to adopt a new behavior is dependent on attitude, social norms, and perceived behavioral control, and that intention leads to the adoption of the behavior itself (Ajzen, 1991).

Since TPB is criticized for its parsimony (Ajzen, 2015), there are many attempts to extend TPB by integrating it with other theories, specifically in the technological adoption of pro-environmental behavior (Klöckner, 2013). The integration either decomposes the existing TPB variables as in the seminal work by Taylor and Todd (1995), Technology Acceptance Model (van Dijk et al., 2016; Zeweld et al., 2017) and Norm Activation Theory (Rezaei et al., 2019) or adds additional variables as in Protection Motivation Theory (Wang et al., 2019), Social Identity Theory (van Dijk et al., 2016) and Value Belief Norm (Price and Leviston, 2014). While these consider aspects of technology adoption, protection against threats, or even the role of groups or individuals within groups, they lack antecedents related to climate change awareness (Masud et al., 2016; Price and Leviston, 2014) or additional variable such as past behavior (Burton, 2014; Menozzi et al., 2015).

Most of the focus of current TPB's literature on sustainable agricultural adoption is on high and middle-income countries, e.g., Australia (Price and Leviston, 2014), Brazil (Senger et al., 2017a), China (Jiang et al., 2018; Wang et al., 2019), or Iran (Rezaei et al., 2019). To our knowledge, only a few cases focus on low-income countries, like Ethiopia (Zeweld et al., 2017) and Malaysia (Chin et al., 2016), indicating a geographical gap in applying the socio-psychological framework to behavior change toward sustainable farming adoption (Samberg et al., 2016). Farmers in the developing world adapt to climate change by adopting different sustainable agricultural practices, while in the developed world, they receive institutional support. In this telecoupled system, local adaptation drives a distal change in the system (Liu et al., 2013), highlighting not only a geographical research but also policy gap.

This research aims to understand the factors influencing farmers' decision to adopt sustainable agricultural practices in the context of climate change in a low-income country. We use the Theory of Planned Behavior (TPB) adapting it to fit the selected case study. More specifically, we: 1) explore the significance of usually considered factors in behavior change theories that influence the adoption of sustainable agricultural practices but are not always included in TPB; and 2) assess the capacity of the revised TPB framework to describe factors that influence farmers adoption practices.

We choose to test and adapt TPB for the case of coffee production in Vietnam, the productivity of which is deeply impacted by climate change (Bunn et al., 2015), and the production of which directly influences the quality of life of smallholder farmers who depend on it for their livelihood (Giovannucci et al., 2004). Vietnam is the second largest coffee exporter in the world (after Brazil) and the top exporter in Robusta coffee (Amarasinghe et al., 2015; Ho et al., 2018). Vietnamese coffee is exported worldwide, with the top recipients in terms of weight and value being United States, Germany, Italy, Spain, and Japan (United Nations, 2019), indicating an extensive geographical coverage and a large trade footprint of the Vietnamese coffee sector. Adopting sustainable coffee production in Vietnam is not only a local issue, but also has a global relevance for climate change adaptation. Understanding the mechanisms driving this adaptation can influence the governance of traded systems.

2. Methodology

To assess, revise, and enhance the Theory of Planned Behavior that explains the factors influencing farmers' decisions to adopt sustainable agricultural practices, we framed our research under the grounded theory approach (Strauss and Corbin, 1994). Through data collection and analysis, theoretical concepts prevail and become core elements for the newly developed theory. The steps we followed under the grounded theory approach are (Fig. 1): 1) iterative literature comparison of different TPB applications and data collection to assess the different versions of the theory through pilot interviews; 2) survey development leading to quantitative data collection; 3) variable construction and hypothesis development based on the extended TPB; 4) data analysis under the original and extended TPB framework using Confirmatory Factor Analysis and Structural equation modeling and; 5) the use of the findings of steps 1 through 4 to generate a revised TPB including the new emergent concepts. Below, we describe the Theory of Planned Behavior, give an overview of our case study, and a description of our methodology.

2.1. Theory of planned behavior

The Theory of Planned Behavior argues that determinants of behavioral intention include an individual's attitude, subjective norms, and perceived behavioral control. Consequently, behavioral intention determines the behavior itself (Ajzen, 1991; Fishbein and Ajzen, 2010) (Fig. 2). These different determinants of behavioral intention are latent variables since they are not measured directly but are constructed based on observable (manifest) variables. Attitude (behavioral belief) refers to the evaluation of the behavior; subjective norm (normative belief) is the evaluation of social acceptance or pressure of the behavior; perceived behavioral control (control belief) is the practicality or perception of ease of performing the behavior; and behavioral intention refers to the motivational factors that influence a given behavior (Sheeran, 2002).

Eclipses show the latent variables and arrows show the structural relationship among the latent variables. The determinants of (behavioral) intention are (individual's) attitude, subjective norms, and perceived behavioral control, and (behavioral) intention determines the behavior itself.

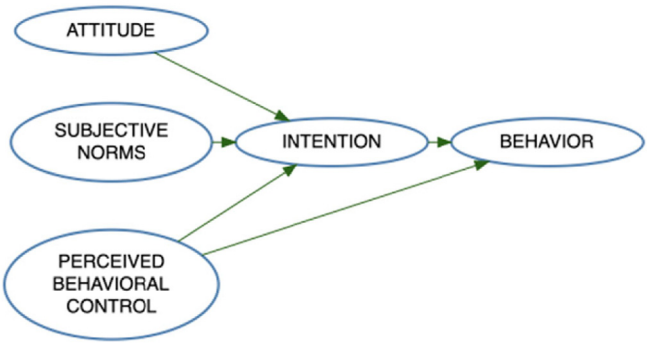


Fig. 2. Conceptual diagram of the original Theory of Planned Behavior (Ajzen, 1991).

2.2. Description of the case study

We collected data from Dak Lak province in the central highland of Vietnam (Fig. 3Fig. 3), the nation's main coffee growing region (Giovannucci et al., 2004), and that with the highest documented impact of climate change on coffee production (Bunn et al., 2015). Dak Lak has 200,000 smallholder farms (~1/3 of the country), and covers 33% of the coffee cultivation area (200,000 ha) and coffee yield (480,000 tons) (GSO, 2019). Within Dak Lak, we selected Ban Me Thuot district as the most ecologically, socially and culturally diverse site with multiple farming practices, different microclimatic conditions and diverse traditions and cultures from various ethnic minorities. The area consists of four farmer membership types (independent farmers, farmers from OLAM company, farmers from Dakman company and farmers from other small cooperatives). Independent farmers and farmers from OLAM company are in Tan Hoa ward within Ban Me Thuot, independent farmers and farmers from Dakman are in the area of Ea Tu, and other small farmer cooperatives are in other areas. Each area has a community leader recruited by the companies for enlisting members. Most farmers are smallholder farmers, regardless of their membership type.

Applying the TPB for this case study, behavioral intention refers to intention to adopt sustainable agricultural practices such as intercropping or reduction in irrigation and organic inputs application; attitude refers to farmers' view on sustainable coffee farming; subjective norms refer to the social circle's views on sustainable coffee farming; and perceived behavior control refers to the ability of coffee farmers to adopt sustainable coffee farming.

The map shows five land cover classes (Kobayashi et al., 2017) forest, tree open, cropland, or other vegetation, water bodies, and urban areas. Coffee farms are classified under tree open. The two survey sites in Ea Tu and Tan Hoa ward are marked. On the right the location of Ban Me Thuot is shown.

2.3. Data collection

2.3.1. Literature review

We reviewed the literature of the different applications of TPB and to explore the way their variables have been constructed. We searched on Science Direct for papers published until June 2018 and later updated with articles until July 2019 with the following search string: "theory of planned behavior" AND "structural equation model" AND sustainable AND agriculture AND farmer. These keywords allowed us to detect articles on sustainable agri-environment management or agricultural technology adoption with the TPB framework using structural equation modeling. From 74 relevant papers retrieved, we retained 36 relevant titles, and after the abstract screening, we maintained 23 articles of which we extracted the variables that were documented to influence farmers' intention to adopt sustainable agricultural practices. We recorded the hypotheses associated with these latent variables and their significance per case, as well as the questions that were used to construct these variables. We used this information to build our extended model.

2.3.2. Qualitative data collection

The pilot interview with farmers and researchers allowed us to consider the input and variability of the interviewees' background and responses according to the grounded theory approach, while the final survey with farmers generated outputs which were used to build our model. Ethical approval was obtained from the Ethics Committee of the Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente.

The pilot interview was conducted in June 2018 with 40 farmers from Ban Me Thuot and its surrounding districts, to ensure the questions were unambiguous and that the items are appropriate for the data analysis (Aubert et al., 2012). We recorded, and transcribed these interviews to understand coffee production under the impact of climate change and farmers' climate perception, and their

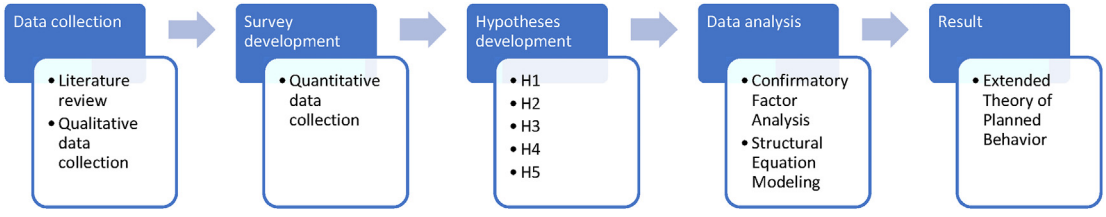


Fig. 1. Workflow of the methodology.

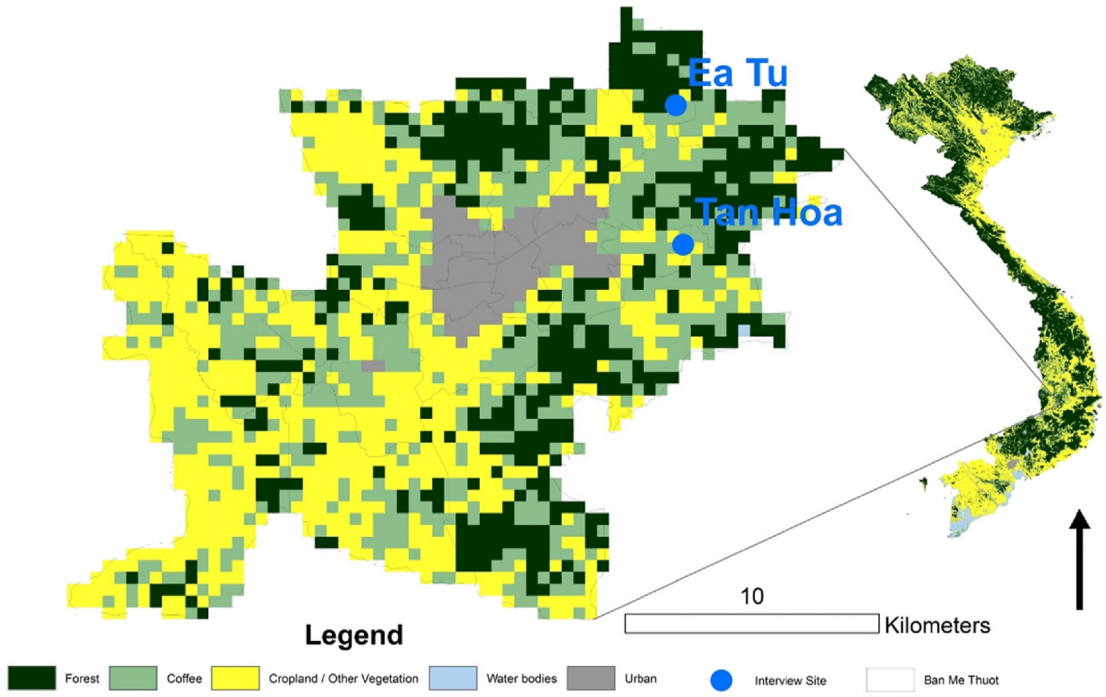


Fig. 3. Ban Me Thuot land cover within Vietnam.

attitude towards adopting sustainable farming practices. We then conducted the semi-structured interviews with representatives from nine policy and research institutes (see Appendix) in December 2018.

Since the purpose of the pilot interviews was to build the final survey, the coding was done by one trained researcher by mapping different statements into concepts and then classifying these categories found in literature (Vollstedt and Rezat 2019). The grounded theory approach allowed us to follow an iterative process moving from data collected through the literature review to concepts and use this to finalize the construction of additional variables that we included in the final survey.

2.3.3. Quantitative data collection

Following survey development process (Chen et al., 2019), the final survey was divided into four sections (Ajzen, 1991; Fishbein and Ajzen, 2010): 1) socioeconomic, 2) farm management, 3) climate perception, and 4) socio-psychological (see Appendix).

For the final analysis, we gathered data from individual face-to-face interviews with farmers in December 2018. There were three trained interviewers, two of which were local researchers, both familiar with the farmers and the socioeconomic background of the region. The survey took 30–50 min to complete. Participants were informed of the research purpose, their voluntary participation, and compensated for their time. The survey utilized convenient sampling, similar to Chin et al. (2016), choosing two representative districts from the Dak Lak province and selected farmers with various farm sizes similar to farm size distribution at the provincial and national levels (Table 1).[1] The calculated minimum sample size from the interviews is 67 for a population of 216,000 coffee farmers based on *alpha* level *a priori* at 0.05, level of acceptable error at 10%, and the standard deviation of the scale at 0.5 (Bartlett et al., 2001). Out of the 150 farmers that were contacted, 110 responded (73% response rate). After missing or inconsistent data was discarded, 93 answers from the final survey were used for final analysis. This exceeds the minimum required sample size (67), therefore we considered this to be representative.

Table 1
Farm size distribution in the survey sample, Dak Lak province, and Vietnam.

	≤0.5ha	0.5–1ha	1–2ha	>2 ha
Designed sample (150 farmers)	32%	31%	26%	11%
Surveyed sample (93 farmers)	14%	45%	34%	6%
Dak Lak province (GSO, 2019)	34%	33%	25%	8%
National (GSO, 2019)	31%	30%	28%	11%

2.4. Data analysis

We constructed the variables based on the interviews' outputs. We conducted confirmatory factor analysis (CFA) to assess the variables' internal consistency with Cronbach *alpha,* omega and average variance extracted to and the reliability of the variable construct (Hair et al., 2013).

We chose SEM to assess the ability of the TPB to account for the causal relationship between the socio-psychological factors leading to the adoption of sustainable agricultural practices for both the original TPB and the enhanced TPB developed for this work and to test a set of different hypotheses related to the socio-psychological factors leading to intention to adopt sustainable agricultural practices. SEM concurrently estimates the relationship between manifest variables and measured items (measurement model), and the relationships among latent variables (structural model) (Chin et al., 2016). SEM is of added value compared to other methods like linear regression, which is only capable of estimating the relationship between manifest variables (Wauters et al., 2010). Within SEM, the measurement model generates factor loadings, and the structural

[1] The original sample of 150 farmers followed the farm size distribution closely, due to non-response and discarded survey sample, the farm size distribution of the final survey is different.

model generates regression coefficients. This two-level construct yields a comprehensive examination of the proposed relationship based on the constructed model (Chin et al., 2016). We developed a set of hypotheses to test the validity of the structural model. We carried out the modeling in R programming language using the lavaan package (Pornprasertmanit et al., 2013; Rosseel, 2018). We reviewed the goodness of fit of the generated models with absolute and relative fit indices (Hair et al., 2013) and compared the improvement of the extended model using ANOVA.

3. Results

3.1. Components of TPB extracted through literature review

The literature revealed that the original TPB model lacks variables and constructs specifics for sustainable agricultural practices (SAP). We identified a gap of TPB catering to characteristics of innovation diffusion, as suggested by the decomposed TPB (Taylor and Todd, 1995). In SAP, "perceived usefulness, ease of use and perceived compatibility" (Taylor and Todd, 1995) translate loosely to financial attitude toward SAP, labor requirement of SAP, and climate change adaptation attitude of SAP. Existing TPB frameworks also lacked the explanatory power of variables like climate perception (Akerlof et al., 2013; Menapace et al., 2015; Niles et al., 2013). Climate change attitude was explored from a climate risk framework in which climate knowledge, climate impact, and climate risk are evaluated. Akerlof et al. (2013) and Niles et al. (2013) argued that climate change knowledge leads to climate risk assessment, which influences the intention for the adoption of sustainable behavior.

Current TPB frameworks lack contextual variables such as social trust. Lobb et al. (2007) analyzed trust in the framework of risk, in which trust from different information sources is antecedent to subjective norms and risk perception. We added the social trust variable to emphasize social credibility and information legitimacy based on Social Identity theory (Fielding et al., 2008; Frank et al., 2011). Thus, trust is considered as a construct for social norm, instead of an independent construct as used in literature (Azadi et al., 2019; Gifford, 2011). The following table summarizes variables from the decomposed and the extended TPB.

3.2. Components of TPB extracted from pilot interviews

Throughout the interviews with farmers and researchers, climate change was the defining factor regarding agricultural practices. Researchers forecasted climate change to impact the agricultural landscape of Vietnam, especially the coffee sector as "drought and increase temperature is going to be the norm" (interviews with IFAD, IPSARD, NCHMF, and VEN). Farmers who have been cultivating coffee since the introduction of coffee plantations in Vietnam in the 1980s (Giovannucci et al., 2004) reported a significant change in the weather pattern in the last ten years and attributed reduction in yield to climate change: "The dry season is hotter [than previous years], the weather is getting warmer. The rain is unpredictable, there are years with much rain, and there are years with little rain" and "Pests are more [frequently observed], coffee decreases productivity with extended heat, or more rain."

Farmers also reported climate change affects not only cultivation and harvesting of coffee but also storage: "there are years the rain comes during coffee cherry picking, this kind of rain does not impact harvest, but impacts drying as the beans will go bad."

When interviewed about influence from their social circles, the level of trust farmers have in those circles emerged as an issue: "depending on how much I trust them I will listen to their advice", or, "if they suggest me techniques out of good will I will listen to their advice".

The three adaptation techniques found in the pilot interviews are intercropping, reduction in irrigation, and organic inputs application (interviews with Central Highland University, VASS, Agri-Logic, and PanNature) similar to that found by Anh et al. (2019a). Intercropping according to farmers are methods that include "planting shading trees such as durian avocado and windbreakers such as pepper and acacia trees", in order to "cool the air and save water" as well as "diversify income". Reduction in irrigation means "watering the right amount of water at the right time" or investment in a "drip-irrigation system". Organic inputs application is to switch to organic fertilizer to "reduce the impact on the environment and health".

3.3. Variable construct for TPB

The questions are selected based on the results of the literature review and the pilot interviews (Table 2, Questionnaire, Appendix 2). The variable construct is based on the final survey. The latent variable Attitude (evaluation of the behavior) is constructed by three items for which data was collected through the surveys: financial attitude toward SAP, labor requirement of SAP, and climate change adaptation attitude of SAP (Jiang et al., 2018). Each item is the aggregation of three different sustainable agricultural practices i.e., financial attitude is the aggregation of financial attitude for intercropping, reduction in irrigation and organic inputs application. Attitude toward SAP productivity was also considered, but dropped, since a validation test observed too much variance, indicating a possible misunderstanding from the respondents.

The latent variable Social Norms (evaluation of social acceptance or pressure of the behavior) was constructed based on two manifest variables: normative belief and social trust. The manifest variable of normative belief (Jones et al., 2016) is the aggregation of normative belief from eight different social groups (family, friend, neighbor, farmer group, coffee buyer, extensionist, village leader and religious leader). The trust variable is the aggregation of social trust from the same eight social groups (Fielding et al., 2008; Frank et al., 2011).

The latent variable Perceived behavioral control was constructed based on five manifest variables: technical control, financial control, labor control, market control and storage control, analogous to the five capitals of sustainable agriculture (Pretty 2008) i.e., human, financial, social, natural and physical capital. After validation testing, only three variables were retained in the measurement model: technical, financial and storage control. We added storage control since storage influences coffee commercialization and quality, and relates to market prices (Hameed et al., 2018). We used storage control as a proxy of market vulnerability after consultation and interviews with farmers, as the shorter the waiting time for more favorable selling price, the more vulnerable the farmer is to accepting low-price offer by one coffee buyer.

We also added past experience as a factor leading to adoption intention since it is key for attitude and provides information on behavioral control (Burton, 2014; Fielding et al., 2008; Menozzi et al., 2015). In terms of agriculture, compatible past agricultural practices for coffee farming in Vietnam dictate the future agricultural practices, because farmers indicated they cannot change their practices too often, thus past experience positively influences intention and behavioral outcome. The latent variable intention is measured by three manifest variables: intention for intercropping, for water-saving irrigation, and for utilizing organic inputs.

Table 2
The components of the original and extended Theory of Planned Behavior. Newly added variables are highlighted in bold.

Theory components (latent variables)	Original Theory of Planned Behavior	Manifest variables from the decomposed Theory of Planned Behavior	Manifest variables from proposed extension of the Theory of Planned Behavior
Attitude	Behavioral beliefs	* Perceived usefulness * Ease of use * Perceived compatibility (Taylor and Todd, 1995)	* Financial attitude toward SAP * Labor requirement of SAP * Climate change adaptation attitude of SAP
Subjective norms	Normative beliefs	* Injunctive norms - "perceptions about what others think the respondent should do" * Descriptive norms - "perception about what others do" (Jones et al., 2016)	* Injunctive norms * **Social trust** - social credibility and information legitimacy based on social identity theory (Fielding et al., 2008; Frank et al., 2011)
Perceived behavioral control	Control beliefs	* Self-efficacy - "confidence in one's own ability to carry out a particular behavior" * Perceived control over behavior - "perceived controllability of behavior" (Armitage and Conner, 2001)	* Technical control - a composite measurement of technical self-efficacy and perceived controllability * Financial control - a composite measurement of both financial self-efficacy and perceived controllability (Senger et al., 2017b) * **Perceive storage control** (Hameed et al., 2018)
Past behavior	N/A	N/A	**Past behavior** (Burton, 2014; Menozzi et al., 2015)
Antecedent	N/A	N/A	**Climate change attitude** (Akerlof et al., 2013; Masud et al., 2016; Niles et al., 2013)

3.4. Hypotheses developed

Based on the original TPB (Ajzen, 1991; Fishbein and Ajzen, 2010), the extended TPB and the literature review (3.1), five hypotheses were developed, testing the variables' relation to one another and to farmers' intention to adopt sustainable agricultural practices (Fig. 4):

H1. Attitude is positively related to the intention to adopt sustainable agricultural practices.

H2. Social norm is positively related to the intention to adopt sustainable agricultural practices.

H3. PBC is positively related to the intention to adopt sustainable agricultural practices.

H4. a - d: Climate perception is positively related to attitude (a), social norm (b), PBC (c), and past behavior (d).

H5. Past intercropping behavior positively affects intention to adopt sustainable agricultural practices.

The eclipses show the latent variables; the arrows show the structural relationship among the latent variables. The hypothesis associated with each relationship is named. The determinants of (behavioral) intention are (individual's) attitude, subjective norms, perceived behavioral control, and past behavior (additional variable in blue eclipse). Climate change is the antecedent to the determinants of (behavioral) intention.

3.5. Data input (from surveys) to the models

The majority of surveyed farmers were male (85%), with 56% being local, 56% of ethnic origin, and 58% being religious (Appendix). Farmers normally locate themselves in the same commune with people having similar background, ethnic origin and religion. They were mostly smallholders with an average farm size of 1.2 ha. The farmers average age is 55 years with an average of 7 years of education. In terms of membership, 71% of farmers had an active membership (30% are part of the farmer association, 30% belong to OLAM production group, 11% belong to the Dakman production group). The rest, 29% are independent farmers. Farmers employing no sustainable practices accounted for 57%, 43% of farmers applies various levels of sustainable agriculture and 3% received certificates of sustainable agriculture.

The farmers' attitude towards SAP (intercropping, water-saving irrigation, and utilizing organic inputs) was divided into financial, adaptation, and labor attitude. The majority of farmers agreed that

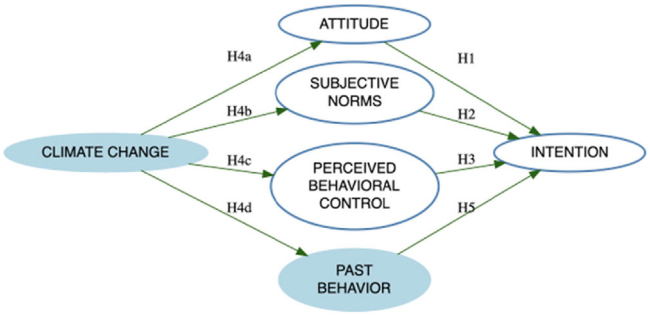


Fig. 4. Hypotheses tested in order to assess the relationships among variables within extended Theory of planned behavior as developed in the current research.

SAP improves the financial, climate adaptation aspect, and that SAP requires more labor for some of the practices and less labor for others, revealing a general positive attitude toward SAP.

The farmer social norms towards SAP were constructed by Injunctive norms (the average encouragement of the social circle toward SAP) and their level of trust towards the social circle. The majority of the farmers declared that their social circle encourages them towards SAP indicating trust in their social circle. Social trust influenced the level of support farmers can receive from others, i.e., the higher the trust, the higher the level of support, in terms of labor, finance, or technical support. Most farmers indicated they can only receive technical assistance and labor swaps (from an average of two sources out of eight), compared to financial support from one source within their social circle.

The farmers' perceived behavioral control was divided into technical, financial, and storage control. For technical control, 64% of farmers reported they have technical knowledge to adopt sustainable practices, and if needed, 69% can obtain support, showing a high level of technical control for SAP adoption. For financial control, only 55% of farmers reported they are financially well-positioned, and 5% of farmers reported they can mobilize money from external sources indicating that farmers are not financially well prepared, 35% of farmers cannot store their coffee since they either do not have proper storage conditions or cannot delay selling as they do not have financial backup resources for immediate family and farm expenses. This indicates that farmers lack infrastructural resources to adopt SAP.

Farmers perception of climate change was not always attributed to climate change itself, still farmers were able to list different climate change patterns: increased temperature, longer dry season,

increased precipitation and aberrant rain season that are supported by climate data from NCHMF (see also Nguyen et al., 2016).

3.6. Confirmatory factor analysis

We performed confirmatory factor analysis to verify the outcomes of the measurement model.

Tables 3a and 3b demonstrate the validity of the variables by three selected measurements (Cronbach's *alpha*, Omega and Average Variance Extracted). Most validity measures fall within the acceptable range (>0.5), except for the latent variable attitude. Since attitude is important conceptually and there is no other measurement for the variable that produces higher reliability and validity, the variable is retained as is.

The goodness of fit indicates that both measurement models are adequate. The Comparative Fit Index is acceptable at 0.80–0.81 for the original and the extended model, close to the cutoff value of 0.9. Standardized Root Mean Square Residual (SRMR) is also good at 0.09 and 0.08 respectively, close to the cutoff value of 0.08 (Hooper et al., 2008).

3.7. Structural equation model outcomes

3.7.1. The model fits

The discriminant validity for both original and the enhanced model satisfies the 0.9 threshold of the Heterotrait-monotrait ratio of correlations (Henseler et al., 2015). The normed χ^2, which was used to assess the model fit, is 2.46–3.64, which shows adequate fit for all models (Hair et al., 2013). Comparative Fit Index is acceptable at 0.81–0.83 for all models, close to the cutoff value of 0.9. Standardized Root Mean Square Residual (SRMR) is also good at 0.08, equal to the cutoff of 0.08 for all models (Hooper et al., 2008). In both models, attitude, subjective norm, and PBC combined, explain 50–55% of the variation in intention to adopt sustainable agricultural practices. We observed an improvement of the predictive power of Intention of the extended model ($R^2 = 0.55$) versus the original model ($R^2 = 0.50$) according to the ANOVA test, at a 5% significance. According to the discriminant validity and the fit indices, the results illustrate that TPB is an appropriate framework for analyzing farmers' intention to adopt sustainable agricultural practices.

3.7.2. Hypothesis testing

Three of the five proposed hypotheses were supported by the models and the data (Table 4). Social norms (H2), PBC (H3) are all significant factors influencing intention to adopt sustainable agricultural practices, whereas attitude (H4) does not significantly influence intention. In addition to that, the antecedent climate perception plays an essential role in forming behavioral determinants (attitude, social norms and perceived behavioral control over the adoption of sustainable agricultural practices).

All coefficients are standardized. *, **, *** denote significance at 10%, 5% and 1%. Eclipses show the latent variables, and arrows show the structural relationship among the latent variables.

The original and the extended model with additional variables (climate change, market and past behavior variables, Fig. 5a and b) show that the most consistent and significant regressions are subjective norms and PBC in regards to (behavioral) intention (H2 and H3). The higher the Social norm, the higher the intention to adopt sustainable agricultural practices (the regression coefficient is moderate at 0.47 with 10% significant). The higher the Perceived behavioral control, the higher the intention to adopt sustainable agricultural practices (the regression coefficient is moderate at 0.51–0.52 with 10% significant).

Attitude and past behavior have an insignificant relationship with intention and a weak negative correlation for both the original and the extended models. Hypotheses 1 and 5 were not supported; hence no conclusion can be made regarding how attitude or past behavior can change intention to adopt sustainable farming practices. For attitudinal belief, this can be explained by the inconsistent answer given for labor attitude, with farmers being ambivalent about whether sustainable agriculture requires more labor or less. In most of the cases of agricultural practices (intercropping, applying organic inputs), general labor requirement was shown to increase significantly, whereas reduction in irrigation requires less labor. Injunctive norm and social trust significantly affect farmers' Social norm (loading factor of 0.8, at 5% significance, Fig. 4b). The variable trust covaries with perceived financial control, which suggests that informal financial arrangement can only be made in tandem of trust.

Climate change attitude positively influenced all determinants leading to intention (attitude, social norms, perceived behavioral control, and past behavior), supporting Hypothesis 4. The high and significant path coefficients (0.70–1.00, 5% significance) indicated that climate change attitude has a strong influence on all other measures. However, while interviewed farmers were familiar with the terms, and their climate observation was similar to climate data, they ranked themselves as non-knowledgeable (30%) or have heard of the term but could not define or apply the knowledge in practice (49%). Only one group leader was comfortable enough to share his knowledge about climate change impacts and adaptation.

3.7.3. Theoretical observations for the extended TPB

In the final step of the grounded theory approach, we used the results from the previous steps to generate an extended TPB. The extended TPB has an extra latent variable (past behavior) and an antecedent (climate perception) and revised contextual variables (trust). The latent variable past behavior did not significantly influence behavioral intention; however, climate change antecedent affects the behavioral determinants. We added the antecedent to the TPB, which improved the TPB fit.

In terms of conceptual contribution, both the original and the extended TPB verify the appropriateness of this socio-psychological framework in explaining the intention to adopt sustainable agricultural practices. The extended model used in this study added a crucial dimension to the original model; the antecedent of climate perception to the theory of planned behavior. The extended theory of planned behavior also includes contextual variables into the latent variable construct i.e., the trust factor within the social norm, and past behavior studied for its influence on behavioral intention.

The extended TPB explains 55% of the variance in intention to adopt SAP compared to 50% of the original TPB. The ANOVA showed

Table 3a
Validity measures of the original model.

	ATT	SN	PBC	INT
Cronbach's alpha	0.53	0.81	0.68	0.85
Omega	0.57	0.81	0.69	0.86
Average Variance Extracted	0.32	0.68	0.52	0.67

Table 3b
Validity measures of the extended model.

	ATT	SN	PBC	PST	CC	INT
Cronbach's alpha	0.53	0.81	0.6	0.58	0.62	0.85
Omega	0.56	0.82	0.62	0.61	0.62	0.86
Average Variance Extracted	0.31	0.69	0.38	0.45	0.46	0.67

Table 4
Hypothesis testing according to regression results and SEM estimation of the original and extended TPB.

Hypothesis	Result	Regressor	Regressand	Original TPB	Extended TPB
H1	Not supported	Attitude	Intention	−0.15	−0.38
H2	Supported	Social norm	Intention	0.47*	0.47*
H3	Supported	PBC	Intention	0.51*	0.52*
H4a	Supported	Climate change	Attitude		1.00**
H4b	Supported	Climate change	Social norm		0.70**
H4c	Supported	Climate change	PBC		0.73***
H4d	Supported	Climate change	Past behavior		0.85***
H5	Not supported	Past behavior	Intention		0.23

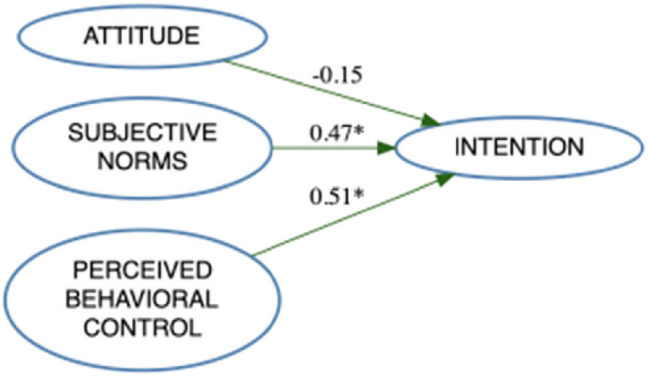


Fig. 5a. Structural equation model of the original Theory of planned behavior.

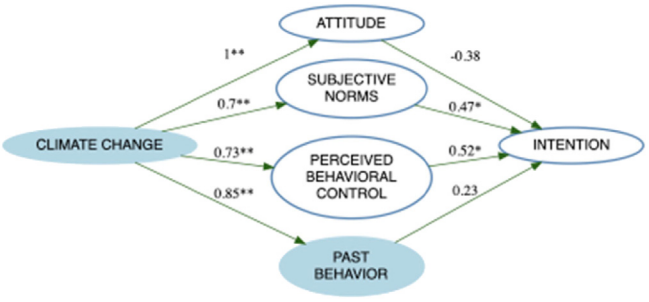


Fig. 5b. Structural model of the extended Theory of Planned Behavior. Filled eclipses show the variables added in the extended model.

a significant difference at 5%, indicating that the extended model better fits the data and the additional variables and antecedent contributes to the improvement.

4. Discussion and conclusions

In this paper, we aimed to understand factors leading to farmers' adoption of sustainable agricultural practices in coffee farms in Vietnam. We adopted the grounded theory approach to extend the original Theory of Planned Behavior to include climate perception and other contextual variables, such as social trust, which we considered to be essential for the case study analyzed. The extended Theory of Planned Behavior presented in this paper fits the data better than the original one and most of our hypothesis were confirmed. Our findings indicated that the adoption of sustainable agriculture is mainly a social issue that relates to climate perception. Social trust was flagged as important in building social norms and financial capital, influencing farmers' adoption of sustainable agricultural practices.

The contributions of this research are dual as it has revealed: the need for a theoretical expansion of the Theory of Planned Behavior to include more variables at a local level and; the mechanisms that need to be considered for the adoption of sustainable coffee farming in Vietnam. Current research on coffee farming in Vietnam is limited to assess technical aspects such as fertilizer use (Byrareddy et al., 2019), irrigation (Amarasinghe et al., 2015) or economic analysis (Anh et al., 2019; Anh and Bokelmann, 2019). This is the first research that takes into consideration socio-psychological characteristics of farmers in their farming decision. After two hundred years of intensive farming (Le et al., 2020) which resulted in reduced biodiversity and degraded environmental conditions, coupled with eminent climate change impacts, Vietnam coffee sector is especially vulnerable, and in need of change. Policy measures that encourage the adoption of sustainable practices are essential for farmers to adapt to climate change. Understanding how to tackle change resistance from a socio-psychological perspective helps policy makers to devise "soft" policies focusing on the social components instead of technical aspects (Anh et al., 2019) that adapt to the context which will have a lasting benefit.

4.1. Adopting sustainable coffee practices in Vietnam

To apply the Theory of Planned Behavior to the local context, we analyzed unstructured interviews using the grounded theory approach. This allowed us to tailor and expand a theory by collecting and qualitatively analyzing empirical evidence (Adnan et al., 2017; Kassie et al., 2015; Wauters et al., 2010). By focusing on the Vietnamese case, we provided a bottom-up adaptation of the theory by adding relevant variables that are both reported in the literature as important but not included in the current theory.

Having a clear understanding of how to cope with climate change locally using sustainable agricultural practices drives farmers to change their attitude, social norms, and perceived behavioral control (Akerlof et al., 2013). The consideration of farmers as heterogeneous in their social identity, with different credibility in different social circles in this research, revealed interesting patterns on the decision making process and their barriers to change. Of particular interest was the fact that social trust was highlighted as a key variable influencing their decision to adopt SAP, in other words, trust is a currency in a shadow economy like Vietnam. This could have management implications, indicating that any top-down climate communication or financial support has to be delivered by a trusted member of the local circle. This is even more relevant for smallholder farmers, who cover 80% of the total coffee farmers in Vietnam, as they operate in a small supply chain, with limited contacts toward potential buyers and members of other groups (Nguyen and Sarker, 2018).

The results showed that Perceived behavioral control is the most significant factor contributing to intention to adopt sustainable agricultural behavior (Chin et al., 2016; Despotović et al., 2019; Jiang et al., 2018). Thus, in order to encourage adoption of sustainable agricultural practices, practitioners should help farmers lift technical, financial and physical barriers (Anh et al., 2019). This

translated to increase in extension services, access to loans and storage for dried beans.

4.2. Rethinking the theory of planned behavior

The inclusion of the variable climate perception to the Theory of Planned Behavior does not only put the theory in the local context but also fits the data better. Such expansion is important since climate perception, influenced by climate observations and climate experience, directly influences climate adaptation (Akerlof et al., 2013; Menapace et al., 2015). Hence, changing climate perception is of paramount importance in changing farmers' behavior towards climate adaptation. First, for climate change perception to impact social norms, climate information has to be "salient, credible and legitimate" (Frank et al., 2011; Markowitz and Guckian, 2018). Secondly, in order for climate communication to influence perceived behavioral control, such information has to be "clear, practical and contextually appropriate" (Moser, 2010). Currently, climate communication focuses on the danger of climate change instead of operational details on how to practice sustainable agriculture to adapt to climate change (Nguyen et al., 2016). Climate change communications that refer to weather variabilities and their direct impact on farms seem to be more pertinent to behavior change than general messages about global warming.

The Theory of Planned Behavior also explained the significance of social norms as a factor that influences behavioral intention (Fielding et al., 2008; Lalani et al., 2016). This provided support for the conceptualization of social norms as injunctive norms and social trust. Social trust within the framework of social identity theory (Fielding et al., 2008) also contributed to the construction of social norms. Social trust is considered an important driver toward adoption of sustainable practices (Azadi et al., 2019; Gifford, 2011) but is not usually empirically studied in the context of behavior change, as has been done in this study. Social trust is set to covary with financial capital, this means that the higher the trust, the more the farmer can secure financial control by borrowing within their social circle (Hurri and Ngoc 2015).

4.3. Limitations and future considerations

One of the main limitations of our study was that it addressed only selected climate change adaptation mechanisms. We included only intercropping, reduction of irrigation and application of organic inputs within the sustainable agricultural practice framework and excluded other adaptation techniques such as reducing tillage (Zeweld et al., 2017), integrating livestock with crops (Senger et al., 2017b). We focused only on those relevant for this research as they occurred from our interviews with Vietnamese coffee farmers. For future research and applications to different case studies, other adaptation mechanisms should be considered if such practices become more common and widely adopted in coffee plantations.

Another limitation of our study was measurement of intention instead of the behavior itself. For example, Armitage and Conner (2001) in their meta-analytic study of TPB models reported that the TPB explain 39% of the variance of intention but only 27% of the variance of behavior. Hence, for future studies, data on the behavior of the famers to understand the mediating effect would be able to reveal more information.

CRediT authorship contribution statement

Nga Nguyen: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Writing – original draft, Visualization. **Evangelia G. Drakou:** Supervision, Writing – review & editing.

Declaration of competing interest

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

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Appendix A. Supplementary data

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