Factors Influencing Farmers' Adoption of Climate Change Adaptation Practices

– Evidence from Vietnam, Laos, and Cambodia

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Abstract

Southeast Asia is among the most vulnerable regions to climate change, and its high dependence on agriculture imposes significant challenges on its farming systems. Given these challenges, farmers' climate change adaptation is becoming increasingly important. Therefore, this thesis explored the interlinkages among – and the influence of – social support, knowledge, and various aspects of farmers' perceptions on their adoption of climate change adaptation practices. Previous research in Southeast Asia has thus far focused on farmers' attitudes towards – or barriers to – adaptation. This thesis goes a step further by providing insights into the underlying factors and how their interlinkages influence adaptation. Structural Equation Modelling was employed to account for the complexity of farmers' adaptation behaviour. The results show that social support, knowledge, and perceived usefulness of adaptation practices have small positive direct effects on farmers' adoption of adaptation practices. Perceived ease of use had a medium-sized positive direct effect, and also mediated the relationship between knowledge and adoption. Perceptions of climate change and its impacts were not found to have significant direct or indirect effects. The thesis concludes that perception should not be studied as a single latent construct when investigating Southeast Asian farmers' adoption of adaptation practices but rather as multiple constructs. The findings contribute to the crucial research efforts needed in the region to understand how farmers' adaptive capacity and food systems' resilience can be strengthened. Thus, the findings also add to policy-relevant literature and provide a good foundation for future research on the development of climate change adaptation policies.

Keywords: Structural Equation Modelling (SEM), Climate Change Adaptation, Southeast Asia, Farmer Behaviour, Sustainable Agriculture.

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Abbreviations

AVE	Average Variance Extracted
CC	Climate Change
CCAP	Climate Change Adaptation Practice
CORR	Correlation
HTMT	Heterotrait-monotrait Ratio
sd	Standard Deviation
SLU	Swedish University of Agricultural Sciences
VIF	Variance Inflation Factor

1. Introduction

1.1 Problem Description

Southeast Asia is one of the world's most vulnerable regions to climate change (Hicks 2021), and its high dependence on agriculture imposes significant challenges on the region's farming systems (IPCC 2007). The fact that cropping systems must be tailored after the specific local climate make them particularly sensitive to unexpected shifts in those conditions (Hatfield et al. 2011), putting the farmers' livelihoods at considerable risk (Resurreccion & Sajor 2008; Chavas & Nauges 2020). Due to the pressing state of these challenges, the role of climate change adaptation practices in farmers' response to climate change is becoming increasingly important (Adger et al. 2007; Reidsma et al. 2010; Hicks 2021). The IPCC (2022a) emphasise this idea and claims that if efforts are not taken to adapt to climate change effectively, the developmental gains in the world are at risk, and millions of already vulnerable people may be pushed further into poverty.

Nonetheless, according to the IPCC (2022b), the current scale and speed of climate change adaptation efforts worldwide are insufficient for ensuring sustainable development. Someshwar (2013) further notes that today's adaptation in response to climate change is primarily reactive, meaning that measures are adopted only after climate change impacts are observed. The author also mentions that to increase the scale and speed of adaptation efforts, create resilient agricultural systems, and avoid unnecessary damages, a shift towards anticipatory adaptive management is highly necessary. Although governmental efforts are necessary to enable a systemic shift to such coping strategies, the lengthy processes associated with policy development in order to go from planning to action inhibit timely responses to the urgent threats imposed by climate change (Resurreccion & Sajor 2008). For this reason, farm-level adaptation efforts are necessary to complement governmental efforts (Reidsma et al. 2010).

Currently, Southeast Asian farmers' adaptive capacity[1] is limited (Davies et al. 2009; Landicho et al. 2019). However, given the potential adverse effects of climate change on this region's economic development, strengthening their adaptive capacity – and thereby inducing adaptive behaviour – is crucial (Masud et al. 2017). In order to do so, the available literature (e.g., Bayard and Jolly (2007), Resurreccion and Sajor (2008), Deressa et al. (2011), Le Dang et al. (2014), and Masud et al. (2017)) indicates that it is necessary to enhance the understanding of

[1] According to the IPCC (2014), adaptive capacity involves having the skills and technologies necessary to adjust to potential damages and the ability to take advantage of opportunities and respond to consequences.

how social and psychological dimensions affect farmers' behaviour. In an effort to decrease this research gap, this thesis focused on how the availability of informal social support, knowledge about climate change and adaptation practices, and various aspects of farmers' perceptions shape their decisions to adopt climate change adaptation practices. Previous studies (e.g., Ndamani and Watanabe (2017) and IPCC (2022b)) have found that social support and knowledge are important factors in building farmers' adaptive capacity. Furthermore, Le Dang et al. (2014) found that farmers' perceptions of climate risks and the effectiveness of adaptation practices influenced Vietnamese farmers' intention to adapt their operations to climate change. However, despite its growing relevance, the literature on the specific ways in which these factors influence Southeast Asian farmers' adaptive behaviour – i.e., their actual adoption of climate change adaptation practices – is scarce (Resurreccion & Sajor 2008; Le Dang et al. 2018).

Various studies outside Southeast Asia have explored the role of knowledge, social support, and perceptions in farmers' environmental behaviour. For example, Pandey et al. (2018) studied the role of climate information and traditional knowledge in climate change adaptation among farmers in the Western Himalayas and found that these two factors both influence adoption behaviour. Furthermore, Momtaz et al. (2020) found that Iranian farmers' belief in climate change, their knowledge about it, and their perceptions of the phenomenon significantly influence their adoption of adaptation practices. Finally, Bayard and Jolly (2007) studied how Haitian farmers' soil conservation behaviour is influenced by their acceptance of social support (aid from others), awareness and attitudes towards erosion problems, perceived susceptibility to and severity of climate change impacts, and perceived benefits from adopting soil conservation practices. They found that perceived susceptibility to and severity of climate change impacted the farmers' awareness of erosion problems, which, in turn, affected their adoption of soil conservation practices. However, previous studies have not thoroughly investigated how different aspects of farmers' perceptions – along with knowledge and social support – jointly impact their adaptive behaviour.

The growing need for farm-level adaptation in Southeast Asia demonstrates the necessity of increasing the understanding of farmers' behaviour in climate change adaptation and the factors affecting their adoption of adaptation practices. Only through gaining such understanding can effective adjustments of current development projects and policy schemes aimed at inducing adaptation be made (Pandey et al. 2018). In extension, achieving such improvements can help secure farmers' livelihoods, expand the usage of sustainable agriculture practices, improve regional and global food security, and strengthen the socio-economic resilience of the Southeast Asian agricultural communities (Zobeidi et al. 2022). This thesis contributes to enhancing this necessary understanding by exploring the interlinkages among Southeast Asian farmers' social support, knowledge, and perceptions in their adaptive behaviour structure, thereby providing a good foundation for future research on this topic.

1.2 Aims and Objectives

In light of the problems outlined above, the overarching aim of this thesis was to analyse the influence of social support, knowledge, and perceptions on Southeast Asian farmers' behaviour in climate change adaptation. The study focused on the Indochinese Peninsula on the mainland of the Southeast Asian region, consisting of Vietnam, Laos, and Cambodia. These three countries provide a good study objective for the Southeast Asian region as they represent all three stages of national-level climate change adaptation readiness, as categorised by Salamanca and Nguyen (2016). Vietnam represents "adaptation pioneers", Cambodia represents "emerging champions", and Laos represents "wait-and-see adaptors". Furthermore, the specific objective of the thesis was to explore the interlinkages among – and the influence of – social support, knowledge, and various aspects of perceptions on Southeast Asian farmers' adoption of climate change adaptation practices. By investigating both psychological processes and economic decision-making, this thesis takes a broader approach than previous research in the region as it better accounts for the complex nature of farmers' adaptation behaviour structure (Chavas & Nauges 2020). Incorporating both kinds of variables is allowed through the application of Structural Equation Modelling (SEM) (Lynne et al. 1988; Bayard & Jolly 2007). The results contribute to filling part of the previously mentioned research gap on the relationship between farmers' perceptions and adaptive behaviour in the Southeast Asian context. Thereby, this thesis contributes to the literature by providing useful information that could assist the design and implementation of climate change adaptation projects and policies in Southeast Asia.

2. Conceptual Framework

The conceptual framework presented in Figure 1: Conceptual framework depicting factors influencing Southeast Asian farmers' adoption of climate change adaptation practices.Figure 1 is developed based on recent literature on social, psychological, and economic drivers of farmers' adoption of climate change adaptation practices. The framework is based on hypothesised interlinkages among seven latent constructs, i.e., social concepts that are not directly observable and therefore are measured using observable indicators (Sturgis 2022). The arrows (i.e., paths) in the framework illustrate the hypothesised direct and indirect relationships among the latent constructs studied in this thesis. The farmers' adoption of climate change adaptation practices (*AdoptionCCAP*) is the latent construct of interest. In addition, the following six influencing factors are included in the framework:

1. Farmers' access to informal social support in times of need (*SocialSupport*)
2. Farmers' self-assessed knowledge about climate change and climate change adaptation practices (*Knowledge*)
3. Farmers' general perceptions of climate change (*PerceptionCC*)
4. Farmers' perceptions of climate change's adverse impacts on their production (*PerceptionImpact*)
5. Farmers' perceived usefulness of climate change adaptation practices in mitigating negative impacts of climate change on agriculture (*PerceptionUse*)
6. Farmers' perceived ease of using climate change adaptation practices (*PerceptionEase*)

These seven latent constructs are represented by the oval shapes in the conceptual framework and are described in further detail in section 3.2. The specific hypotheses tested are outlined in sections 2.1 and 2.2. The framework excludes socio-demographic variables such as age, gender, education, and income, as the results on their effects presented in previous research carried out in developing countries are inconsistent.

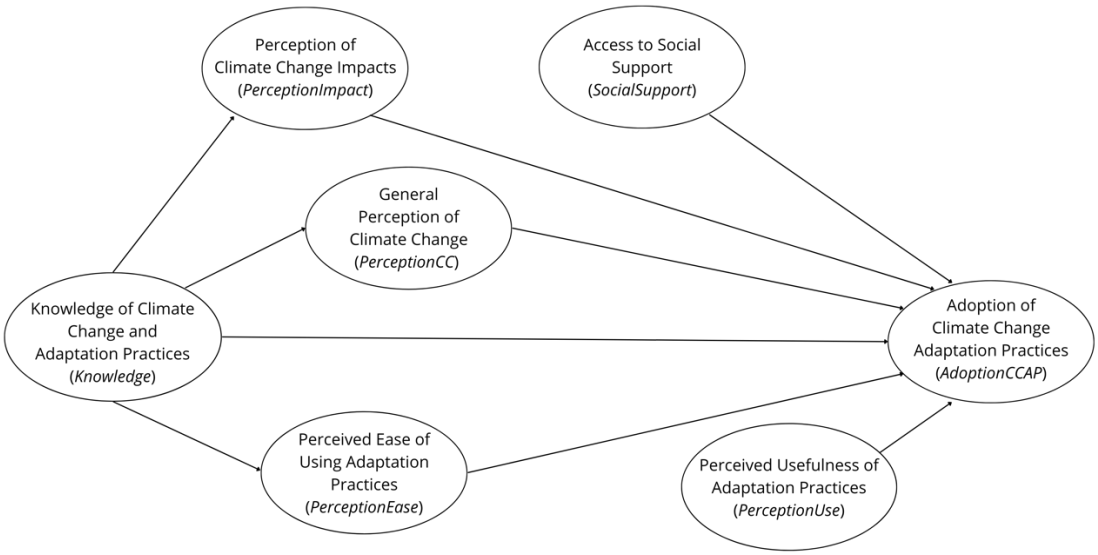

Figure 1: Conceptual framework depicting factors influencing Southeast Asian farmers' adoption of climate change adaptation practices.

2.1 Hypothesised Direct Effects

2.1.1 Social Support and Adoption

Social support available at a time of need has been found to act as a stress buffer, making stress-exposed farmers better equipped to cope with external challenges such as climate change or natural disasters (Cohen et al. 2000; Resurreccion & Sajor 2008). In Southeast Asia, such mechanisms include, for example, informal loans, group sharing losses, and supporting the worst off in the community (Resurreccion & Sajor 2008). As such, social safety nets are a critical factor in building adaptive capacity in vulnerable communities (IPCC 2022b). Conversely, a lack of social support can have a negative effect on farmers' decision to adopt climate change adaptation practices by restricting their adaptive capacity (Masud et al. 2017). Nevertheless, Resurreccion and Sajor (2008) argue that the previous research on informal social security mechanisms – i.e., support from peers, family, and friends – related to climate change adaptation is limited in the Southeast Asian context. They argue that the efficacy of these mechanisms in the region must be better understood to facilitate farmers' adoption of climate change adaptation practices and that additional research efforts should aim to investigate this relationship. The following hypothesis was formulated to contribute to filling this research gap:

H1: Social support available at a time of need positively affects farmers' adoption of climate change adaptation practices (*SocialSupport → AdoptionCCAP).*

2.1.2 Knowledge and Adoption

Extensive literature supports that knowledge about climate change and adaptation practices are essential factors in determining farmers' adaptation behaviour (e.g., Gebrehiwot and van der Veen (2013), Piya et al. (2013), and Masud et al. (2017)). Such knowledge can be created through, for example, agricultural extension programs or previous experiences with climate change adaptation practices or climate change impacts (Sharma et al. 2009; Ndamani & Watanabe 2017). A high level of knowledge about climate change creates awareness of the issues it poses to the farmers (Mileti & Sorensen 1990; Deressa et al. 2011). In turn, that awareness can affect attitudes towards the problem and strengthen individuals' perceptions of its impacts, thus stimulating their willingness to take action to minimise its adverse effects (McCown 2005; Lee et al. 2015). Moreover, worldwide studies (e.g., Rivera (2014), Kichamu et al. (2018), and Pandey et al. (2018)) find that a lack of knowledge and understanding of climate change adaptation is a significant barrier hindering farmers from adopting adaptation practices. Gifford et al. (2011) and Rivera (2014) explain that one reason for that being is that a lack of knowledge may make the farmers unable to see how climate change adaptation can be applied to their own operations, thus negatively affecting their adoption of adaptation practices. Based on these worldwide results, the following hypothesis was formulated regarding this relationship for Southeast Asian farmers:

H2: Knowledge about climate change and adaptation practices positively influence farmers' adoption of climate change adaptation practices (*Knowledge → AdoptionCCAP).*

2.1.3 Perceptions of Climate Change and Adoption

The role of farmers' perceptions in climate change adaptation has been highlighted in numerous studies (e.g., Grothmann and Patt (2005), Arbuckle et al. (2013), Masud et al. (2017)). For example, in a study among Haitian farmers, Bayard and Jolly (2007) concluded that higher perceptions of their susceptibility to and the severity of climate change positively influenced the farmers' adaptive behaviour. Joshi et al. (2017), Belay et al. (2017), and Pandey et al. (2018) found similar results in their studies of Nepalese, Ethiopian, and Indian farmers, respectively. To the author's knowledge, no previous studies have investigated these relationships in a Southeast Asian context with decisive results. However, Le Dang et al. (2014) concluded that Vietnamese farmers who perceive climate change as a phenomenon negatively affecting their operations have a higher intention to adopt adaptation practices. This thesis, therefore, hypothesised that this relationship extends to the farmers' actual adoption of climate change adaptation practices in the studied region. Thus, the following two hypotheses were formulated:

H3: Farmers' general perceptions of climate change positively influence their adoption of climate change adaptation practices (*PerceptionCC → AdoptionCCAP).*

H4: Farmers' perceptions of the adverse impacts of climate change on their production positively influence their adoption of climate change adaptation practices (*PerceptionImpact → AdoptionCCAP)*.

2.1.4 Perceptions of Climate Change Adaptation Practices and Adoption

Previous studies show that farmers' perceptions of adaptation practices' ease of use and usefulness in mitigating negative impacts of climate change on agriculture are two factors, among others, that govern their decisions to adopt such practices. This relationship can be explained by drawing from Davis's (1989) insights on users' adoption of information technology and innovation. The author mentions that a system's ease of use refers to both physical and mental effort and explains that the easier and more useful a system is, the more of the user's efforts can be allocated to other activities. This improvement in the allocation of efforts, in turn, improves the users' general performance, Davis argues. Previous studies have presented findings which suggest that such a relationship exists. For example, Greiner and Gregg (2011) and Asseng and Pannell (2012) confirm the importance of perceived ease of use and usefulness for Australian farmers' decision to adopt climate change adaptation practices. Additionally, Meijer et al. (2015), Ndamani and Watanabe (2017), and Tesema and Abera (2019) found evidence for these factors' importance to farmers in sub-Saharan Africa. However, the literature on these relationship in a Southeast Asian context is scarce and mainly focuses on farmers' intention to adapt their operations rather than their actual adaptation. One example is Le Dang et al.'s (2014) study on Vietnamese farmers. They found evidence that high perceptions of adaptation measures' effectiveness – in addition to high perceptions of climate change as an issue – increases the farmers' intention to adopt adaptation practices. Based on these previous findings, the following two hypotheses were formulated:

H5: Farmers' perceptions of the usefulness of climate change adaptation practices in mitigating negative impacts of climate change on agriculture positively affect adoption (*PerceptionUse → AdoptionCCAP).*

H6: Farmers' perceptions of the ease of using climate change adaptation practices positively affect adoption (*PerceptionEase → AdoptionCCAP).*

2.2 Hypothesised Indirect Effects

In addition to the direct effects outlined in the previous section, this thesis studied three mediating effects reflecting the indirect influence of knowledge on Southeast Asian farmers' adoption of climate change adaptation practices. The three factors hypothesised to mediate this relationship are (i) farmers' general perceptions of climate change, (ii) farmers' perceptions of the adverse impacts of climate change on their production, and (iii) farmers' perceptions of adaptation practices' ease of

use. These indirect effects are hypothesised based on, e.g., Fankhauser and Tol (1997) and Meijer et al. (2015), who recognise the underlying role of knowledge in creating awareness of climate change's existence. They claim that by creating such awareness, perceptions of climate change and its adverse impacts are fostered. Masud et al. (2017) and Tiet et al. (2022) also found these relationships through farmer surveys in Malaysia and Vietnam, respectively. They further argue that increased perceptions can enhance adaptive behaviour. These findings support the idea of an indirect relationship between Southeast Asian farmers' knowledge and adoption of climate change adaptation practices. In this relationship, the farmers' perceptions of climate change and its adverse impacts on their production act as mediators. Therefore, the following two hypotheses were formulated:

H7: Farmers' general perceptions of climate change mediate the relationship between their knowledge about climate change and adaptation practices and their adoption of such practices (*Knowledge → PerceptionCC → AdoptionCCAP).*

H8: Farmers' perceptions of the adverse impacts of climate change on their production mediate the relationship between their knowledge about climate change and adaptation practices and their adoption of such practices (*Knowledge → PerceptionImpact → AdoptionCCAP).*

Finally, previous studies suggest that farmers' perceptions of adaptation practices' ease of use may mediate the relationship between their knowledge about climate change and adaptation practices and adoption. For example, Ndamani and Watanabe (2017) found that Ghanaian farmers who are informed about climate change and measures to mitigate its adverse impacts on their operations to a higher degree perceive different adaptation practices as easy to use. In a literature review on technology adoption in agriculture, Chavas and Nauges (2020) further note that people generally have a higher motivation to adopt easier systems, as they are then allowed to learn by doing to a greater extent. The authors also relate the motivation to adopt new technologies to the farmers' ability to learn the new systems, i.e., their possibility to gain experience and their access to information on them from, e.g., agricultural extension services and social connections. This idea suggests that knowledge about climate change and adaptation practices plays a role in determining the farmers' perceptions of such practices' simplicity. Therefore, the following hypothesis was formulated:

H9: Farmers' perceptions of climate change adaptation practices' ease of use mediate the relationship between their knowledge about climate change and adaptation practices and their adoption of such practices (*Knowledge → PerceptionEase → AdoptionCCAP).*

3. Data and Methodology

3.1 Household Survey

This thesis uses past survey data on households' climate change adaptation and food security collected by Ha et al. (2021). The data has 1017 observations with no missing data. The survey was carried out between May and November 2021 in the Son La province in Vietnam, the Saysomboun and Vientiane provinces in Laos, and the Oddar MeanChey province in Cambodia.[2] These provinces are all highly vulnerable to climate change and are thus relevant to this thesis. The data were gathered in two steps, in which farm household representatives were invited to participate. Stratified random sampling was employed in the first step. In the second step, convenience sampling was applied to Son La, Saysomboun, and Vientiane, while random sampling was carried out in Oddar MeanChay. For collection, the mobile phone-based survey software KoBoToolbox was utilised. This software is designed specifically for field data collection in challenging environments (for example in humanitarian emergencies) and developing countries, and is widely used by organisations and researchers in various fields of study (KoBo n.d.). The survey included three sections: (i) demographic information and agricultural production, (ii) climate change perceptions and adaptation, and (iii) food insecurity and response. For this thesis, a selected number of survey items from sections (i) and (ii) were utilised. The variable measurements are described in further detail in section 3.2.

3.2 Variable Measurement

The 35 survey items initially considered in the model were all structural statements eliciting the farmers' access to informal social support in times of need (*SocialSupport*), self-assessed knowledge about climate change and adaptation practices (*Knowledge*), general perceptions of climate change (*PerceptionCC*), perceptions of climate change's adverse impacts on production (*PerceptionImpact*), perceived usefulness of climate change adaptation practices in mitigating climate change impacts on agriculture (*PerceptionUse*), perceived ease

[2] Initially, the Son La, Saysomboun, and Oddar MeanChay provinces were selected as strata. However, due to social restriction regulation during the Covid-19 pandemic, Vientiane was included as an additional province in Laos.

of using climate change adaptation practices (*PerceptionEase*), and self-reported behaviour related to the adoption of climate change adaptation practices (*AdoptionCCAP*). These statements were evaluated using 5-point Likert scale measurements indicating the strength of the respondents' feelings towards the respective statement. Regarding the survey items eliciting the farmers' general perceptions of climate change, the respondents were asked to state their level of agreement with actual impacts that have been observed in the region since the 1960s (Lasco et al. 2011). Furthermore, the farm-level adaptation practices included in the survey to elicit the farmers' perceived usefulness and ease of using such practices, as well as their adoption of them, are all common climate change adaptation strategies in Southeast Asia (Resurreccion & Sajor 2008; Shrestha et al. 2018). An overview of the variable measurements, i.e., the indicators and their associated latent constructs, is provided in

Table 1.

Table 1: Latent Constructs and Associated Indicator Variables

Latent Construct	Construct Description	Indicator Variable Description	Indicator Variable Name	Measurement Scale
Social Support	Informal social support available to farmers in times of need	Help from the respondent's relatives or friends is available if needed	HelpIntend	Strongly disagree-Strongly agree
		The respondent has received help (money, goods, or labour) when needed	HelpReceived	
		The respondent has sent help (money, goods, or labour) to others when they have needed it	HelpSent	
Knowledge	Farmers' knowledge about climate change and adaptation practices	Respondent's self-assessed level of knowledge about climate change	KnowledgeCC	Very poor-Very good
		Respondent's self-assessed level of knowledge about climate change adaptation practices	InformedCCAP	Very poor-Very good
		Information volume respondent has received on climate change adaptation practices from agricultural extension services	InfoVolume	None or very little-Very much
Perception CC	Farmers' general perceptions of climate change	*In the past ten years, the respondent perceives…*		Strongly disagree-Strongly agree
		The summers to have gotten hotter	HotterSummer	
		The dry seasons to have become longer	LongerDrys	
		The annual amount of rain to have decreased	LessRain	
		Extreme climate events to have become more frequent	OftenECE	

Perception Impact	Farmers' perceptions of the adverse impacts of climate change on their households' production	*Climate change has affected the respondent's…*		Not at all-Very much
		Crop production	Crop	
		Agroforestry	Agroforestry	
		Livestock production	Livestock	
		Collection of forest products (e.g., firewood and vegetables)	ForestCollect	
		Household's food supply	HHFoodSupply	
		Household's income	HHIncome	
		Family members' health	HHHealth	
Perception Ease	Farmers' perceived ease of using climate change adaptation practices	*The ease of...*		Very difficult-Very easy
		Using climate-tolerant crops	ease_CTCrops	
		Intercropping	ease_Intercrop	
		Switching to new cash crops	ease_CashCrops	
		Building irrigation systems	ease_Irrigation	
		Enhancing livestock's health during extreme events	ease_ LivestockHealth	

		Using climate-tolerant animal breeds	ease_CTAnimals	
Perception Use	Farmers' perceived usefulness of climate change adaptation practices in mitigating negative impacts of climate change on agriculture	*The usefulness of…*		Very little-Very much
		Using climate-tolerant crops	use_CTCrops	
		Intercropping	use_Intercrop	
		Switching to new cash crops	use_CashCrops	
		Building irrigation systems	use_Irrigation	
		Enhancing livestock's health during extreme events	use_ LivestockHealth	
		Using climate-tolerant animal breeds	use_CTAnimals	
Adoption CCAP	Farmers' adoption of climate change adaptation practices	*The respondent activity related to the following climate change adaptation practices:*		1. I am not doing this and I am not willing to 2. I haven't done it yet but I am thinking of doing it 3. I haven't done it I am preparing to do it very soon 4. I have started doing it 5. I have been doing it well for months already
		Using climate-tolerant crops	CTCrops	
		Intercropping	Intercrop	

Switching to new cash crops	CashCrops
Building irrigation systems	Irrigation
Enhancing livestock's health during extreme events	CTAnimals
Using climate-tolerant animal breeds	LivestockHealth

3.3 Data Analysis

The data was analysed using Structural Equation Modelling (SEM) – an increasingly popular statistical method (Hair et al. 2017). This method is well-suited for estimating complex systems and interrelationships between observed variables and latent constructs (Sturgis 2022). Because of these features, SEM is commonly used in behavioural economic research (ibid.). As there is little prior knowledge about how the variables studied in this thesis are related in a Southeast Asian context, an exploratory approach was taken. For exploratory research utilising SEM – where the aim is to explain the variance in the variable(s) of interest in order to develop theories – Partial Least Squares SEM (PLS-SEM) is suitable (Hair et al. 2017). PLS-SEM is compatible with survey data measured using 5-point Likert scales as it is a non-parametric method and thus does not rely on an assumption of normality (Muthén 1984; Latif 2020). Hence, the PLS-SEM-method was applied in this thesis.

This thesis follows the procedure recommended by Hair et al. (2017) for conducting PLS-SEMs, with a few steps eliminated due to the use of secondary data and the nature of the conceptual framework.[3] The procedure includes the following stages:

1. Specifying the Structural Model
2. Specifying the Measurement Model
3. Data Examination
4. Model Estimation
5. Assessing the Measurement Model Results
6. Assessing the Structural Model Results
7. Interpreting the Results and Drawing Conclusions

As indicated in stages 1 and 2, SEMs consist of two parts; the structural model, which assesses the relationships between latent constructs, and the measurement model, which assesses the relationship between the individual latent constructs and

[3] For the complete list of steps, see Hair et al. (2017).

their respective indicators (Hair et al. 2017). The measurement model specified in this thesis is reflective, meaning that the indicators are treated as observable manifestations of an underlying construct (ibid.). The model was subsequently estimated using the PLS Algorithm in SmartPLS – a software specifically designed for performing PLS-SEMs. SmartPLS allows for simultaneous testing of the measurement model and the structural model (Latif 2020). It also allows for simple modelling and produces well-organised result reports.

In assessing the measurement model and structural model, standard quality criteria determining the predictive capability suggested by Hair et al. (2017) were used. The measurement model was assessed based on its internal consistency reliability and validity. The specific measures used in this assessment include the model's composite reliability, convergent validity, and discriminant validity.[4] Internal consistency reliability was determined using Cronbach's alpha (α) and composite reliability rho_c, for which values of $0.6 < \alpha < 09$ are satisfactory. Furthermore, convergent validity was assessed based on the outer loadings and the Average Variance Extracted (AVE). The limit values applied for these indicators were > 0.6 and > 0.5, respectively. Finally, discriminant validity was determined based on the Fornell-Larcker criterion and the Heterotrait-monotrait ratio (HTMT). In order for the Fornell-Larcker criterion to be fulfilled, the square root of the AVE for a particular construct (Y_x) should be greater than its highest correlation with any other construct (Y_y). Regarding HTMT, values must be < 0.8. A summary of the specific measurements applied, including their corresponding limit values, is provided in Table 2.

Table 2: Measurement Model Assessment Criteria and Corresponding Limit Values (Based on Hair et al. (2017))

Criteria	**Indicator**	**Limit Value**
Internal consistency reliability	Cronbach's alpha	$0.6 < x < 0.9$
	Composite reliability rho_c	$0.6 < x < 0.9$
Convergent validity	Outer loadings	> 0.6
	Average Variance Extracted (AVE)	> 0.5
Discriminant validity	Fornell-Larcker criterion	$\sqrt{AVE}_{Y_x} > CORR_{Y_xY_y}$
	Heterotrait-monotrait ratio (HTMT)	< 0.8

Once construct reliability and validity were established, the structural model was examined for potential collinearity issues by verifying that the Variance Inflation Factor (VIF) value for each set of predictors was $0.2 < VIF < 0.5$. The structural model was further assessed based on the results generated from the Bootstrapping[5]

[4] An explanation of the applied assessment criteria's specific functions for determining the quality of the model is provided in Table A1 in Appendix 1.

[5] Bootstrapping is a non-parametric inferential technique where a specified number of subsamples are randomly drawn with replacement from the original data set. In the thesis, the bootstrapping procedure was performed with 5000 subsamples, as recommended by Hair et al. (2017).

and Blindfolding[6] procedures in SmartPLS. In the assessment, the key criteria for determining the model's predictive capacity mentioned by Hair et al. (2017) were used; the significance of the path coefficients ($p < 0.05$), the model's predictive power, the effect sizes of the endogenous latent constructs, and the predictive relevance.[7] The authors explain that the values of the path coefficients are standardised and normally fall within the interval -1 to 1. A value close to 1 indicates a strong positive relationship and vice versa for negative values. A value close to 0 indicates a weak relationship. Hair et al. further state that the model's predictive power is indicated by its R^2-value, where values of 0.75, 0.50, or 0.25 are considered substantial, moderate, or weak, respectively. They also note that the effect sizes – indicated by the constructs' respective f^2-values – can be categorised as large ($f^2 \geq 0.35$), medium ($0.15 \leq f^2 < 0.35$), small ($0.02 \leq f^2 < 0.15$), or not meaningful ($f^2 < 0.02$). Finally, the authors state that the structural model has predictive relevance if the Q^2-value for a specific endogenous latent variable is > 0. An overview of the specific measurements applied, including their corresponding limit values, is provided in Table 3.

Table 3: Structural Model Assessment Criteria and Corresponding Limit Values (Based on Hair et al. (2017))

Criteria	**Indicator**	**Limit value**	
Significance of path coefficients	-	$p < 0.05$	
Model's predictive power	R^2	≥ 0.5	
Effect size	f^2	No meaningful effect:	< 0.2
		Small effect:	$0.02 \leq f^2 < 0.15$
		Medium effect:	$0.15 \leq f^2 < 0.35$
		Large effect:	≥ 0.35
Predictive relevance	Q^2	> 0	

If the measurement model or the structural model does not meet the specified requirements, modifications are necessary (Kline 2011). Steps 1-6 may thereby be repeated multiple times until a satisfactory model is achieved. As a result of the measurement model assessment in this thesis, nine observed items (*Agroforestry*, *HHHealth*, *ForestCollect*, *Livestock*, *OftenECE*, *InfoVolume*, *Irrigation*, *ease_Irrigation* and *use_Irrigation*) were deleted from the model due to low outer loadings (< 0.6). These variables are, therefore, not presented in further detail in the following chapters. The complete model assessments are presented in section 4.2.

[6] Blindfolding is a technique used for sample re-use, in which data points are systematically deleted in order to generate a prognosis of their original values (Ringle et al. 2015). For this thesis, the default setting of seven as the omission distance (i.e., the number of blindfolding rounds) in SmartPLS was used.

[7] Explanations of the applied assessment criterias' specific functions for determining the quality of the model are provided in Table A1 in Appendix 1.

4. Results

4.1 Descriptive Statistics

4.1.1 Demographic Characteristics

In order to provide a deeper understanding of the surveyed farmers, this section presents descriptive statistics on their demographic characteristics.[8] Vietnamese farmers represent 40.81 per cent of the responses, compared to 29.79 per cent for Cambodian farmers and 29.40 for Laotian farmers. This distribution somewhat accurately represents the countries' relative population sizes (The World Bank 2022). The sample consisted of 52.02 per cent male and 47.98 per cent female respondents. Overall, 62.64 per cent of the respondents were the head of their household. Regarding the farmers' subjective evaluation of their income category, a majority of the respondents (56.64 per cent) stated that they were comfortable. 27.83 per cent consider themselves poor, and 4.72 per cent consider themselves very poor. Only 8.85 and 1.97 per cent report themselves being well-off and very well-off, respectively. Concerning the farmers' education level, 26.16 per cent have no education, 33.53 per cent have attended primary school, 21.44 secondary school, and 13.57 high school. Only 5.30 per cent have a higher education. The mean age in the sample was 41.99 years, and the mean of years engaged in farming was 23.18. The mean distance to the nearest market was 6.30 km.

In comparing the results between the countries, the mean distance to the nearest market was the longest for Laotian farmers (8.36 km), followed by Cambodian (6.97 km) and Vietnamese farmers (4.32 km). Furthermore, Cambodian farmers were found to be the oldest and have the most experience in farming, with a mean age of 48.29 years and an average of 27.30 years engaged in farming. Laotian farmers' mean age and experience were 41.45 and 21.23 years, respectively. Vietnamese farmers were the youngest and had the least experience on average – 37.76 and 21.59 years, respectively. However, the education level was the highest among Vietnamese farmers, where 31.33 per cent had a secondary school education, and 17.59 per cent had completed high school. In Laos, the same values were 21.40 and 14.05 per cent, respectively, and in Cambodia, 7.92 and 7.59 per cent, respectively. 25.78 per cent of Vietnamese farmers had a primary school education, compared to 32.44 per cent of Laotian farmers and 45.21 of Cambodian

[8] A summary of the descriptive statistics on the sample's demographic characteristics is provided in Table A2 in Appendix 2.

farmers. 20.96 per cent of Vietnamese farmers and 21.07 per cent of Laotian farmers had no schooling. This number is notably higher for Cambodian farmers, where 38.28 per cent had no schooling. Regarding university graduates, Laos stands out with 9.03 per cent compared to Vietnam's 2.65 per cent and Cambodia's 0.99 per cent. Regarding the respondents' evaluation of their income category, the responses across the countries are fairly similar. However, the Laotian farmers are somewhat better off than Vietnamese and Cambodian farmers, with a notably higher percentage of farmers categorising themselves as well-off (14.38) or very well-off (4.01).

4.1.2 Latent Constructs

Presented in Table 4 are descriptive statistics (total mean, country mean, and standard deviations) on the included indicator variables and their associated latent constructs, sorted by country. Regarding the farmers' perceptions of climate change, the mean scores show that the farmers across all three countries somewhat agree with all included statements ($mean_{total} = 3.94$). By country, the average score across the statements is lowest for Laos (2.99), followed by Cambodia (4.28) and Vietnam (4.38). Laotian respondents were also found to have the lowest perceptions of the adverse impacts of climate change on their production (2.86). Both Vietnamese and Cambodian respondents perceive high impacts of climate change on their production, although the mean is marginally higher for Vietnamese farmers (3.88) than for Cambodian farmers (3.53).

Moreover, considering the ease of using the studied climate change adaptation practices, the large number of Vietnamese farmers affects the mean score across the studied countries (2.82). On average, Vietnamese farmers perceive the practices as notably easier (3.35) than Laotian (2.48) and Cambodian (2.42) farmers. Regarding the usefulness of the practices in mitigating negative impacts of climate change on agriculture, however, the respondents were found to be more similar across the countries. On average, the farmers perceived the practices as moderately useful ($mean_{total} = 2.90$), although the mean among Vietnamese farmers was found to be slightly higher (3.30) than among Laotian (2.74) and Cambodian farmers (2.51), respectively. With only marginal differences between the countries, the respondents assess their knowledge about climate change and adaptation practices as poor ($mean_{total} = 2.13$, $mean_{vietnam} = 2.33$, $mean_{laos} = 2.02$, $mean_{cambodia} = 1.96$). Moreover, considering available informal social support, Vietnamese and Cambodian farmers somewhat agree with all statements on average ($mean_{vietnam} = 4.09$, $mean_{cambodia} = 3.36$), whereas Laotian farmers are neutral ($mean_{laos} = 2.77$).

Table 4: Descriptive Statistics on Influencing Latent Constructs (by country)

		Vietnam		Laos		Cambodia		Total	
Latent Construct	**Indicator**	**Mean**	**sd**	**Mean**	**sd**	**Mean**	**sd**	**Mean**	**sd**
Perception CC	Hotter Summer	4.56	0.60	2.47	1.08	4.32	1.09	3.87	1.30
	Longer Drys	4.33	0.55	3.28	1.05	4.31	0.95	4.01	0.97
	LessRain	4.24	0.62	3.21	1.13	4.20	0.94	3.93	1.00
	Average	**4.38**	**0.59**	**2.99**	**1.09**	**4.28**	**0.99**	**3.94**	**1.09**
Perception Impact	Crop	4.25	0.89	3.18	1.13	3.71	1.17	3.77	1.14
	Food Supply	3.61	1.09	2.53	1.16	3.67	1.01	3.31	1.20
	HHIncome	3.77	0.93	2.86	1.09	3.77	1.02	3.50	1.09
	Average	**3.88**	**0.97**	**2.86**	**1.13**	**3.72**	**1.07**	**3.53**	**1.14**
Perception Ease	ease_ CTCrops	3.46	0.86	2.32	0.80	2.36	1.09	2.80	1.07
	ease_ CashCrops	3.06	0.91	2.34	0.77	2.04	0.96	2.54	0.99
	ease_ Irrigation	2.83	1.14	2.58	0.92	2.54	1.16	2.67	1.10
	ease_ Livestock Health	3.72	0.83	2.76	1.88	2.52	1.18	3.08	1.42
	ease_ CTAnimals	3.65	0.80	2.41	0.66	2.63	1.11	2.98	1.04
	Average	**3.35**	**0.91**	**2.48**	**1.01**	**2.42**	**1.10**	**2.82**	**1.12**
Perception Use	use_ CTCrops	3.16	0.76	2.53	1.17	2.43	0.96	2.76	1.01
	use_ CashCrops	3.08	0.94	2.51	1.27	2.24	0.98	2.66	1.12
	use_ Irrigation	3.59	1.25	3.28	1.35	2.69	1.06	3.23	1.28
	use_ Livestock Health	3.51	1.01	2.90	2.09	2.59	0.97	3.06	1.46
	use_ CTAnimals	3.14	0.72	2.49	1.15	2.62	0.88	2.79	0.96
	Average	**3.30**	**0.94**	**2.74**	**1.41**	**2.51**	**0.97**	**2.90**	**1.17**
Knowledge	Knowledge CC	2.41	0.82	1.89	0.96	1.96	0.95	2.12	0.93
	Informed CCAP	2.25	0.89	2.15	2.02	1.95	0.94	2.13	1.34
	Average	**2.33**	**0.85**	**2.02**	**1.49**	**1.96**	**0.94**	**2.13**	**1.14**
Social Support	Help Received	3.92	0.98	2.85	1.05	3.24	1.41	3.40	1.23
	HelpIntend	4.04	0.83	2.62	1.05	3.29	1.30	3.40	1.21
	HelpSent	4.30	0.63	2.85	0.97	3.55	1.24	3.65	1.12
	Average	**4.09**	**0.81**	**2.77**	**1.02**	**3.36**	**1.32**	**3.49**	**1.19**

Finally,

Table 5 presents the responses for the variable of interest –*AdoptionCCAP*. The table displays the country means (including standard deviations), the total means (including standard deviations), and the percentage of farmer responses to each statement for all adaptation practices included in the final model. The table indicates that the sampled Vietnamese farmers, again, affect the overall mean ($mean_{total} = 2.94$). Vietnamese farmers have, on average, adopted adaptation practices ($mean_{vietnam} = 4.19$), whereas Laotian and Cambodian farmers have not ($mean_{laos} = 2.07$, $mean_{cambodia} = 2.08$). However, the mean scores among the Laotian and Cambodian farmers indicate that they are generally thinking of adopting such practices.

Table 5: Descriptive Statistics on AdoptionCCAP (by country)

		1. I am not doing this and I am not willing to	2. I haven't done it yet, but I am thinking of doing it	3. I haven't done it but I am preparing to do it very soon	4. I have started doing it	5. I have been doing it well for months already	Mean (sd)
Indicator	**Country**	**%**					
CTCrops	Vietnam	0.02	0.06	0.01	0.16	0.76	4.58 (0.90)
	Laos	0.30	0.56	0.38	0.36	0.25	1.96 (0.99)
	Cambodia	0.36	0.46	0.02	0.10	0.06	2.04 (1.16)
	Total						**3.06** (1.62)
CashCrops	Vietnam	0.19	0.22	0.02	0.07	0.51	3.78 (1.43)
	Laos	0.56	0.38	0.36	0.25	0.00	2.11 (1.27)
	Cambodia	0.45	0.33	0.07	0.11	0.05	1.71 (0.95)
	Total						**2.67** (1.57)
Intercrop	Vietnam	0.08	0.20	0.06	0.17	0.49	3.49 (1.69)
	Laos	0.38	0.36	0.25	0.00	0.01	1.86 (1.31)
	Cambodia	0.52	0.35	0.05	0.06	0.02	1.97 (1.17)
	Total						**2.56** (1.63)
Livestock Health	Vietnam	0.02	0.12	0.03	0.12	0.70	4.71 (0.82)
	Laos	0.36	0.25	0.00	0.01	0.00	2.67 (1.44)
	Cambodia	0.32	0.42	0.07	0.12	0.08	2.47 (1.47)
	Total						**3.44** (1.62)
CT Animals	Vietnam	0.01	0.06	0.00	0.07	0.86	4.37 (1.13)
	Laos	0.25	0.00	0.01	0.00	0	1.76 (0.75)
	Cambodia	0.34	0.29	0.07	0.14	0.15	2.22 (1.24)
	Total						**2.94** (1.61)

4.2 Model Estimation, Assessment, and Modification

4.2.1 Measurement Model

Figure 2 shows the complete model estimated and assessed in this section. The rectangle shapes represent the observed indicator variables which the respective latent construct is assumed to give rise to. As mentioned in section 3.3, nine indicators (*Agroforestry*, *HHHealth*, *ForestCollect*, *Livestock*, *OftenECE*, *InfoVolume*, *Irrigation*, *ease_Irrigation* and *use_Irrigation*) were deleted from the model due to low factor loadings (< 0.6). The deleted factors are presented in dotted rectangles connected to their associated construct by dotted arrows. Through this measure, internal consistency reliability, composite reliability, convergent validity, and discriminant validity were established. The reliability and convergent validity results are presented in

Table 6, along with each factor's loading on their associated construct. The discriminant validity results are reported in Table 7.

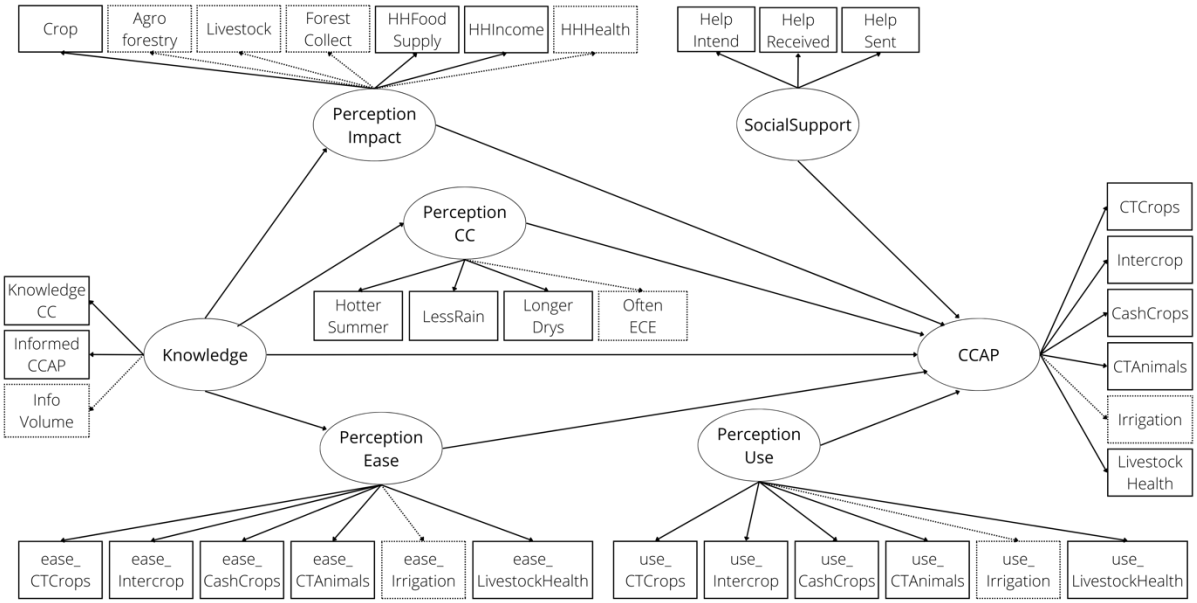

Figure 2: Complete model.

Table 6: Measurement Model Assessment – Reliability and Convergent Validity Results[9]

Construct	Indicator	Loading	α	Composite Reliability rho_c	AVE
AdoptionCCAP	CTAnimals	0.846	0.855	0.896	0.634
	CTCrops	0.856			
	CashCrops	0.761			
	Intercrop	0.699			
	LivestockHealth	0.807			
Knowledge	InformedCCAP	0.806	0.737	0.874	0.777
	KnowledgeCC	0.951			
PerceptionCC	HotterSummer	0.890	0.786	0.866	0.685
	LessRain	0.756			
	LongerDrys	0.831			
PerceptionImpact	Crop	0.843	0.788	0.873	0.697
	HHFoodSupply	0.821			
	HHIncome	0.840			
PerceptionEase	ease_CTAnimals	0.820	0.832	0.882	0.600
	ease_CTCrops	0.802			
	ease_CashCrops	0.705			
	ease_Intercrop	0.742			
	ease_LivestockHealth	0.797			
PerceptionUse	use_CTAnimals	0.762	0.825	0.877	0.588
	use_CTCrops	0.800			
	use_CashCrops	0.751			
	use_Intercrop	0.761			
	use_LivestockHealth	0.760			
SocialSupport	HelpReceived	0.924	0.875	0.922	0.799
	HelpIntend	0.834			
	HelpSent	0.920			

[9] For limit values, see Table 2.

Table 7: Measurement Model Assessment – Discriminant Validity Results[10]

Fornell-Larcker Criterion

	Adoption CCAP	Knowledge	Perception CC	Perception Impact	Perception Ease	Perception Use	Social Support
AdoptionCCAP	*0.796*						
Knowledge	0.342	*0.881*					
PerceptionCC	0.299	0.165	*0.827*				
PerceptionImpact	0.257	0.073	0.473	*0.835*			
PerceptionEase	0.669	0.269	0.291	0.291	*0.774*		
PerceptionUse	0.456	0.221	0.273	0.371	0.485	*0.767*	
SocialSupport	0.469	0.240	0.403	0.305	0.430	0.343	*0.894*

HTMT

	Adoption CCAP	Knowledge	Perception CC	Perception Impact	Perception Ease	Perception Use	Social Support
AdoptionCCAP							
Knowledge	0.409						
PerceptionCC	0.322	0.176					
PerceptionImpact	0.295	0.081	0.574				
PerceptionEase	0.786	0.302	0.336	0.340			
PerceptionUse	0.537	0.266	0.315	0.446	0.582		
SocialSupport	0.527	0.282	0.437	0.351	0.495	0.399	

4.2.2 Structural Model

The structural model reflects the paths hypothesised among the latent constructs and corresponds to the conceptual framework specified in Figure 1. As shown in Table 8, all VIF values are within the interval $0.2 < VIF < 5$, verifying that collinearity among the constructs is not a critical issue in the structural model.

[10] For limit values, see Table 2.

Table 8: VIF Values

	Adoption CCAP	Knowledge	Perception CC	Perception Impact	Perception Ease	Perception Use	Social Support
Adoption CCAP							
Knowledge	1.118		1.000	1.000	1.000		
Perception CC	1.439						
Perception Impact	1.422						
Perception Ease	1.502						
Perception Use	1.450						
Social Support	1.414						

Table 9 presents the structural model assessment. Initially, the significance of the path coefficients was considered to test the hypothesised direct effects presented in section 2.1. The results presented in

Table 9 reveal that access to informal social support in times of need (H1), knowledge about climate change and adaptation practices (H2), perceived usefulness of adaptation practices (H5), and perceived ease of using adaptation practices (H6), respectively, have positive and significant effects on Southeast Asian farmers' adoption of climate change adaptation practices. The results also reveal that neither farmers' general perceptions of climate change (H3) nor their perceptions of climate change's adverse impacts on their production (H4) significantly affect their adoption. Hence, H1, H2, H5, and H6 were supported, whereas H3 and H4 were not.

Mediation analysis was performed to evaluate the indirect effects of farmers' knowledge about climate change and adaptation practices on their adoption of climate change adaptation practices, as hypothesised in section 2.2. The results presented in

Table 10 reveal that neither farmers' general perceptions of climate change (H7), nor their perceptions of climate change's adverse impacts on their production (H8) have significant mediating roles in the relationship between knowledge about climate change and adaptation practices and adoption. However, the results show that perceived ease of using climate change adaptation practices (H9) does have a significant mediating role in the same relationship. Hence, H9 was supported, whereas H7 and H8 were not.

Moreover, the R^2-value for *AdoptionCCAP* indicates that 52 per cent of the change in this variable can be attributed to the other latent constructs in the model. This R^2-value is considered moderate. Furthermore, the f^2-values for the significant relationships among the constructs reveal that *Knowledge* has a small effect on *AdoptionCCAP* (0.035). The effect of *PerceptionUse* and *SocialSupport* on *AdoptionCCAP* are also small (0.021 and 0.043, respectively), whereas *PerceptionEase* shows a medium effect on *AdoptionCCAP* (0.336). Finally, the Q^2-values are all > 0, indicating that the model has predictive relevance.

Table 9: Structural Model Assessment[11]

	Path coefficients		
	β (Sig.)	**95% Confidence Interval***	**f^2 (Sig.)**
SocialSupport → AdoptionCCAP (H1)	0.172 (0.000)	[0.122, 0.224]	0.043 (0.002)
Knowledge → AdoptionCCAP (H2)	0.136 (0.000)	[0.085, 0.185]	0.035 (0.009)
PerceptionCC → AdoptionCCAP (H3)	0.036 (0.142)	[-0.012, 0.082]	0.002 (0.513)
PerceptionImpact → AdoptionCCAP (H4)	-0.011 (0.672)	[-0.061, 0.039]	0.000 (0.911)
PerceptionEase → AdoptionCCAP (H5)	0.492 (0.000)	[0.439, 0.541]	0.336 (0.000)
PerceptionUse → AdoptionCCAP (H6)	0.122 (0.000)	[0.074, 0.169]	0.021 (0.011)
Knowledge → PerceptionCC	0.165 (0.000)	[0.104, 0.224]	0.028 (0.009)
Knowledge → PerceptionImpact	0.073 (0.024)	[0.006, 0.134]	0.005 (0.289)
Knowledge → PerceptionEase	0.269 (0.000)	[0.216, 0.318]	0.078 (0.000)

	R^2 (Sig.)	**Q^2**
AdoptionCCAP	0.520 (0.000)	0.324
PerceptionCC	0.027 (0.007)	0.015
PerceptionImpact	0.005 (0.282)	0.003
PerceptionEase	0.072 (0.000)	0.042

*Bias Corrected

Table 10: Mediation Analysis

	Total Effect (Sig.)	**Direct Effect (Sig.)**		**Specific Indirect Effect (Sig.)**
Knowledge → AdoptionCCAP	0.274 (0.000)	0.136 (0.000)	**Knowledge → PerceptionCC → AdoptionCCAP (H7)**	0.006 (0.155)
			Knowledge → PerceptionImpact → AdoptionCCAP (H8)	-0.001 (0.710)
			Knowledge → PerceptionEase → AdoptionCCAP (H9)	0.132 (0.000)

[11] For limit values, see Table 3.

5. Discussion

In analysing the interlinkages among – and the influence of – social support, knowledge, and various aspects of perceptions on Southeast Asian farmers' adoption of climate change adaptation practices, the results revealed multiple positive and significant relationships. Specifically, the results indicate that the studied farmers' adoption of climate change adaptation practices is positively influenced by the availability of informal social support, their knowledge about climate change and adaptation practices, their perceptions of adaptation practices' usefulness in mitigating negative impacts of climate change on agriculture, and their perceptions of such practices' ease of use. These findings are in line with previous worldwide research (e.g., Cohen et al. (2000), Grothmann and Patt (2005), Gebrehiwot and van der Veen (2013), Abera and Tesema (2019)) and thus provide further empirical support for the theorised positive effect of each latent construct on farmers' adoption of climate change adaptation practices.

The positive effect of available informal social support on farmers' adoption of adaptation practices ($\beta = 0.172$, $p < 0.001$) indicates that farmers experiencing a strong support structure in their community are more likely to adapt their operations. These results corroborate Cohen et al.'s (2000) and Resurreccion and Sajors' (2008) arguments that the availability of social support when needed may have a stress-buffering effect, serving as a facilitator in the farmers' decision to adopt adaptation practices. An underlying reason for the role of social support may be that farmers feel safer trying new techniques in their operations when feeling that they will not be left alone in a time of need. This feeling could be seen as a way of sharing the risk associated with adopting new practices, which could incentivise the farmers to experiment with those practices to a greater extent. Experimentation may subsequently allow for learning-by-doing and accurately determining the practices' merits. These factors have previously been shown to increase the likelihood of adopting new practices and may have had a larger effect than social support had they been included separately in the structural model (Ndamani & Watanabe 2017).

Furthermore, the results of this thesis confirm the findings of Asseng and Pannell (2012) and Ndamani and Watanabe (2017) – that perceptions of climate change adaptation practices' usefulness has a positive effect on farmers' adoption ($\beta = 0.122$, $p < 0.001$). This relationship is conceivably intuitive from an economic perspective; a farmer would think it counterproductive to spend resources on an adaptation practice they do not believe will help them reduce the negative impacts of climate change on their agricultural production. A more feasible option for the farmer in such a situation would be to do nothing and avoid risking their resources. However, believing in the usefulness of such practices is also a crucial component of farmers' adaptive capacity (Grothmann & Patt 2005). Thus, the positive

relationship found may also be explained theoretically by considering that high perceptions of adaptation practices' usefulness in mitigating negative impacts of climate change on agriculture may indirectly enhance the farmers' adoption behaviour by strengthening their adaptive capacity.

Moreover, the results indicate that knowledge about climate change and adaptation practices significantly affects farmers' adaptive behaviour ($\beta = 0.136$, $p < 0.001$). As suggested by Meijer et al. (2015) and Masud et al. (2017), having knowledge about these two aspects creates awareness of future consequences of climate change, thus increasing the farmers' ability to predict potential implications to their practices. Mileti and Sorensen (1990) argue that part of this effect can be explained by how knowledge increases the understanding of climatic warning signals, which, in turn, increases the likelihood of responding to the threat with protective or adaptative actions. This proposed relationship corroborates with the findings of Engler et al. (2021) – that knowledgeable farmers generally find an increased motivation to adopt adaptation practices proactively rather than reactively. Furthermore, knowledgeable farmers are also better equipped to determine the appropriate extent of adaptation due to their better understanding of the inherently dynamic climate systems. Thus, by avoiding adopting too inflexible or sensitive systems, they are more likely to gain good experiences with the adaptation practices. Through such experiences, they are allowed to increase their knowledge even further, which, in turn, has a positive effect on the farmers' adoption of the practices (Ndamani & Watanabe 2017). Thus, the positive effect of knowledge about climate change and adaptation practices on farmers' adoption behaviour is meaningful.

Additionally, the relationship between knowledge about climate change and adaptation practices and behaviour is significantly mediated by the perceived ease of using such practices. A possible explanation for this relationship is that farmers' perceptions of the ease of using adaptation practices is relative to their level of knowledge, as suggested by Abera and Tesema (2019). This relationship can be decerned across all studied countries by looking at the survey results presented in Table 4; Vietnamese farmers have the highest level of knowledge on average and consider the adaptation practices to be the easiest. Laotian farmers report the next highest level of knowledge and perceptions of adaptation practices' simplicity, while Cambodian farmers report the lowest numbers on both variables. This finding also gives further insight into Gifford et al.'s (2011) and Rivera's (2014) ideas that a lack of knowledge impedes farmers' ability to connect their thoughts on climate change adaptation practices to how such practices could mitigate the negative impacts of climate change on their production. The result presented in this thesis suggests that considering the farmers' perceived ease of using adaptation practices in, e.g., education programs may aid in overcoming that impediment. Such consideration could be taken by, for example, personalising information on climate change adaptation practices to a greater extent. By communicating the information relative to the specific farmer's operations and level of knowledge, the farmer could readily perceive climate change adaptation practices as easy, thereby gaining a higher motivation to adopt them.

Looking at the direct effect of farmers' knowledge about climate change and adaptation practices on the perceived ease of using such practices, it is positive, significant, and larger than the direct effect of knowledge on farmers' adoption of

adaptation practices ($\beta = 0.269$, $p < 0.001$). This result suggests that the previously mentioned creation of awareness and favourable attitudes that come with increased knowledge make the practices seem simpler to the farmers to a greater extent than it directly contributes to their adaptive behaviour. This increase in the perceived ease of use, in turn, affects the farmers' adaptive behaviour, causing the indirect effect of knowledge on adoption. However, the strongest effect on behaviour results directly from the farmers' perceptions of the ease of using climate change adaptation practices ($\beta = 0.336$, $p < 0.001$). The result indicates that the easier the farmers find adaptation practices, the more likely they are to adopt them. Similar to the farmers' perceptions of the practices' usefulness, their perceptions of the practices' ease of use is a component of their adaptive capacity (Grothmann & Patt 2005). Thus, this aspect may induce the adoption of climate change adaptation practices for similar reasons. However, the relatively stronger direct effect of the perceived ease of use suggests that this quality is more important in the farmers' adoption decision compared to perceived usefulness.

One reason for this result may be the order in which farmers consider usefulness and ease of use when approaching the decision to adopt adaptation practices. Drawing from Davis's (1989) findings regarding users' adoption of information technology and innovation, a system's ease of use may be an antecedent to its usefulness in a user's decision to adopt that system. Davis further notes that the usefulness of adopting a system may be outweighed by the difficulty of using it, leading the potential user to decide not to adopt the practice. These results provide insight into Abera and Tesemas' (2019) findings on farmers' level of knowledge about climate change and adaptation practices. Since the results of this thesis reveal that the knowledge about these aspects is low in all countries studied (see Table 4), the farmers have a low threshold for what they consider difficult. Given such a relationship, the potential usefulness of adopting a practice may easily be outweighed by its level of difficulty. In other words, if a practice's ease of use is considered prior to its usefulness and the practice is perceived as too difficult, its potential usefulness will not matter as the decision not to adopt it has already been made.

Moreover, the effects on farmers' adoption behaviour generated by their general perceptions of climate change and their perceptions of its adverse impacts on their production could not be determined based on the results presented in this thesis ($\beta_{PerceptionCC} = 0.036$, $p = 0.142$, $\beta_{PerceptionImpact} = -0.011$, $p = 0.672$). These results contradict those of previous worldwide studies on these relationships – e.g., Bayard and Jollys' (2007) study on Haitian farmers, a study by Joshi et al. (2017) on Nepalese farmers, and a study by Momtaz et al. (2020) on Iranian farmers – where both variables have been shown to be significant preconditions to adaptive behaviour. Neither do these variables have significant mediating effects in the relationship between knowledge about climate change and adaptation practices and Southeast Asian farmers' adoptive behaviour ($\beta_{PerceptionCC} = 0.006$, $p = 0.155$, $\beta_{PerceptionImpact} = -0.001$, $p = 0.710$). The previously mentioned ideas by Gifford et al. (2011) and Rivera (2014) – that the farmers may be unable to connect their awareness of climate change and attitudes towards adaptation practices to how such practices could be applied to their production – may be one explanation for these insignificant relationships. As the results presented in Table 4 reveal, the

respondents, on average, have high general perceptions of climate change and perceive its adverse impacts on their production to be considerable. However, as the farmers lack awareness of how these practices may aid in tackling the changing climate and how they can be applied in their own operations, their perceptions provide no insight into the variability in the adoption of adaptation practices.

5.1 Implications

The findings of this thesis are relevant for policy development and future research on farmer behaviour in climate change adaptation. Firstly, as a significant effect of the availability of informal social support was found, the idea that it could have a stress-buffering effect on the farmers is supported. Policymakers should, therefore, acknowledge such support as an enabling factor for farmers' adoption of adaptation practices when planning for future development projects. The same is true for the farmers' perceptions of adaptation practices' usefulness in mitigating the negative impacts of climate change on agriculture. As this variable was found to have a positive influence on adoption, policymakers should aim to increase the perceived usefulness through, for example, education efforts by agricultural extension services. Also, policymakers should recognize that farmers' perceived usefulness of adaptation practices increases when learning that a social connection has successfully implemented such a practice (Ndamani & Watanabe 2017; Orifah et al. 2021). As Pandey et al. (2018) note, the adoption of climate change adaptation practices is contagious, and thus, positive feedback effects could potentially result from offering guidance to farmers planning to implement such practices.

Education efforts also play an important role in the farmers' development of knowledge about climate change and adaptation practices. The significant direct and indirect effect of knowledge in this relationship highlight the importance of following up on the achievements of education efforts and evaluating to which aspects of the farmers' adaptive capacity those efforts contribute. Doing so can help improve the effectiveness of the efforts, which may boost farmers' adoption of climate change adaptation practices. The significant mediating effect of perceived ease of use in the relationship between farmers' knowledge about climate change and adaptation practices and adoption behaviour provides a good example of how such improvements may be achieved. This result suggests that one way to boost adoption further is to communicate the content of education programs and information campaigns in a way that helps farmers perceive the practices as easy. In order to achieve that goal, the education material could, for example, be customised to a greater extent. Through customisation, the farmers' ability to connect their perceptions of adaptation practices to how they would fit their own practices may improve, which would elevate their confidence about their adaptability and stimulate adoption. Policymakers and agricultural extension services should consider these results when planning future education efforts.

Moreover, the non-significant results regarding the effects of farmers' general perceptions of climate change and its adverse impacts on their adoption of adaptation practices suggest that alterations of the model defined in this thesis should be tested. As these results differ from those of previous studies in other countries, further investigations into these relationships in a Southeast Asian

context are needed to substantiate these differences. Special attention should be given to what the farmers consider to be the baseline climate scenario and how their perceptions of climate change and its adverse impacts differ from their general belief in climate change as an environmental, economic, and social issue. However, the fact that most of the direct effects included in the structural model are significant emphasises Grothmann and Patts' (2005) point that the number of factors determining farmers' adaptive behaviour is high. This fact reflects the complex nature of farmers' behavioural structures and suggests that multiple impactful strategies could be employed to foster farmers' adoption of climate change adaptation practices. Thus, additional research is necessary to deepen the knowledge of the interlinkages among the latent constructs influencing farmers' adoption of adaptation practices and how local conditions affect their interconnections.

5.2 Further Research

In order to ensure the accuracy of future development projects and education efforts, a broader understanding of the specific functions of social support should be sought after. Therefore, further studies should consider pursuing closer examinations of the different kinds of informal social support offered in the vulnerable communities in question. Further research could also consider expanding the analysis to explore if a similar effect on farmers' adoption behaviour can be obtained through formal social support, such as international economic aid. Additionally, the small effect of the farmers' perceptions of adaptation practices' usefulness on their adaptive behaviour adheres to Davis's (1989) finding that other factors may predetermine this variable. As an initial step, further studies should, therefore, investigate whether perceived usefulness mediates the relationship between the perceived ease of using adaptation practices and the adoption of them. Based on those findings, education programs by agricultural extension services should be adjusted.

Due to time and financial constraints, further improvements to the structural model presented in this thesis and additions to its complexity were not possible. Therefore, only a moderate amount of the variation in farmers' adoption of climate change adaptation practices could be explained through the model. In order to increase the variance explained, future research should consider altering the structural model presented by including additional mediating effects. For example, there is support in the literature for testing the mediating effect of farmers' perceived usefulness of climate change adaptation practices in the relationship between knowledge and farmers' adoption of such practices (e.g., Apata (2011) and Belay et al. (2017)). Considering Davis's (1989) and Abera and Tesemas' (2019) findings, this variable may also mediate the relationship between perceived ease of using adaptation practices and adoption, as well as between farmers' perceptions of climate change and adoption. As these relationships were hypothesised to be less meaningful, they were omitted from this thesis to adhere to the time limit. However, adding such effects to the model in future studies would be warranted.

Future research should also consider adding various moderating effects to the structural model. For example, there is ample support in the literature for a positive

effect of access to agricultural extension services on farmers' knowledge development regarding climate change and adaptation practices, as well as their perceptions of climate change (e.g., Gebrehiwot and van der Veen (2013), Belay et al. (2017), and Zobeidi et al. (2022)). Adding this variable as a moderator of the effect of, for example, farmers' general perceptions of climate change on adoption of adaptation practices may provide an improved idea of its role in farmer behaviour in climate change adaptation. Also, Orifah et al. (2021) found that both education and years of experience in farming had positive moderating effects on Nigerian rice farmers' perceptions of adaptation practices' usefulness. Additionally, Maddison (2007) and Ishaya and Abeje (2008) found that African farmers' perceptions of climate change increases with experience in farming. These authors' significant results give reason to explore the same effects in the setting of Vietnam, Laos, and Cambodia. Testing the moderating effects of these variables may provide further insight into the effect of the farmers' perceived usefulness of climate change adaptation practices on their adaptive behaviour.

5.3 Limitations

Similar to Bayard and Jollys' (2007) study on farmers' adoption of climate change adaptation practices, a limitation of this thesis is the fact that the latent construct on farmers' adoption behaviour was based on their self-reported behaviour rather than their observed behaviour. Thus, this thesis could not fully examine how farmers' responses to climate change are influenced and whether or not there is a discrepancy between reported and actual behaviour. Another limitation of this thesis was the lack of data on the sampled farmers' adaptive capacity. Modelling such a relationship explicitly, as part of a more complex structural model, may have allowed a greater portion of the variation in the farmers' adoption of climate change adaptation practices to be explained. However, the insights generated through this thesis have relevance for the planning of future policy and research projects in Southeast Asia as they contribute to improving the understanding of how social and psychological variables influence farmers' adoption of climate change adaptation practices.

6. Conclusions

Due to the high vulnerability of the Southeast Asian agricultural sector, expanding the farmers' adoption of climate change adaptation practices is essential to ensure food security, livelihoods, and sustainable development in the region. In order to gain insight into how such adaptive behaviour can be explained, this thesis studied the influence of farmers' perceptions, social support, and knowledge on farmers' adoption of climate change adaptation practices in Southeast Asia. While previous studies in this region have mainly focused on farmers' attitudes towards adaptation or barriers to adopting adaptive measurements, this study highlights the social and psychological drivers of farmers' adaptive behaviour. By including how the interlinkages among the studied latent constructs influence adoption behaviour, this thesis accounted for the complexity of farmers' adaptive behaviour structure. To the author's knowledge, this thesis is the first attempt to model these complex interrelationships in a Southeast Asian setting with decisive results. Thus, this thesis contributes to the existing literature on farmer behaviour in climate change adaptation in the Southeast Asian context.

The results presented in this thesis signify that farmers' behaviour in climate change adaptation is a complex issue due to the vast number of factors determining their adaptive behaviour. However, it can be concluded that social support and knowledge are two factors influencing Southeast Asian farmers' adoption behaviour. It can also be concluded that farmer perception should not be studied as a single latent construct when investigating Southeast Asian farmers' adoption of adaptation practices but rather as multiple constructs. Such a distinction between the various aspects of farmers' perceptions is important to understand how the effectiveness of education efforts can be improved and thereby induce further farm-level climate change adaptation. Nevertheless, additional research efforts must be undertaken to improve the understanding of the specific social and psychological influencing factors and how their interlinkages affect Southeast Asian farmers' adoption of adaptation practices. The insights on the influencing factors presented in this thesis lay a good foundation for future research on Southeast Asian farmers' behaviour in climate change adaptation. Such research will be crucial to enable an expansion of proactive farm-level adaptation efforts in Southeast Asia, which will be essential in reducing the region's vulnerability to future adverse climate change impacts.

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Popular Science Summary

Southeast Asia is among the world's most vulnerable regions to climate change, and its high dependence on agriculture imposes significant challenges on its farming systems. Given these challenges, farmers' implementation of practices to reduce the adverse impacts of climate change on their production, i.e., climate change adaptation practices, is becoming increasingly important. Therefore, this thesis explored the interlinkages among – and the influence of – social support, knowledge, and various aspects of farmers' perceptions on their adoption of climate change adaptation practices. Previous research in Southeast Asia has thus far focused on farmers' attitudes towards – or barriers to – adaptation. This thesis goes a step further by providing insights into the underlying factors and how their interlinkages influence adaptation. Structural Equation Modelling was employed to account for the complexity of farmers' adaptation behaviour. The results show that the farmers are more likely to adopt climate change adaptation practices the higher their value of one or more of the following factors:

- Access to informal social support (i.e., help from friends or relative in the form of money, labour, or goods) in times of need
- Knowledge on climate change and adaptation practices
- Perceived usefulness of adaptation practices in mitigating negative impacts of climate change on agriculture
- Perceived ease of using adaptation practices

The results also show that the farmers' knowledge affects their perceived ease of using adaptation practices, which, in turn, affects their adoption of such practices. The farmers' perceptions of climate change and its adverse impacts on their production were not found to have statistically significant direct or indirect effects. The thesis concludes that perception should not be studied as a single item when investigating Southeast Asian farmers' adoption of adaptation practices but rather as multiple items. The findings contribute to the crucial research efforts needed in the region to understand how farmers' adaptive capacity and food systems' resilience can be strengthened. Thus, the findings also add to policy-relevant literature and provide a good foundation for future research on the development of climate change adaptation policies.

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Appendix 1

Table A1: Explanation of the Applied Assessment Criteria's Specific Functions for Determining the Quality of the Measurement Model and Structural Model.

Model Assessed	Assessment criteria	Function
Measurement model	Cronbach's alpha and Composite reliability rho_c	A measurement of multiple indicators ability to measure the same thing, i.e., their associated latent construct (Hair et al. 2017). The reason for including both measurements is that while Cronbach's alpha may be considered as a too conservative measurement of internal consistency reliability, composite reliability rho_c can be considered as too liberal, according to Hair et al. (2017). The authors argue that the true reliability value for the particular latent construct normally lies within the values of the two measures.
	Convergent validity	Shows that indicators that are meant to measure the same latent construct are, in fact, related (Glen n.d.).
	Discriminant validity	Shows that indicators that are not meant to measure the same latent construct are, in fact, unrelated (Glen n.d.).
Structural model	Significance of path coefficients	Shows the statistical significance of the hypothesized relationships among the latent constructs (Hair et al. 2017).
	Model's predictive power	Indicates the amount of variance in the endogenous constructs of interest that is explained by the exogenous constructs linked to it in the model, i.e., the exogenous latent constructs' joint effect on the endogenous latent construct (Hair et al. 2017).
	Effect sizes of endogenous latent constructs	The change in the model's predictive power had a certain exogenous construct been omitted from the model (Hair et al. 2017).
	Predictive relevance	Exhibits the accuracy with which the model predicts data not used in the model estimation (Hair et al. 2017).

Appendix 2

Table A2: Summary of Descriptive Statistics on the Sample's Demographic Characteristics

		Vietnam	Laos	Cambodia	Total
Variable	**Option**		**%**		
Country		40.81	29.40	29.79	100.00
Gender	Female	48.19	43.14	52.48	47.98
	Male	51.81	56.86	47.52	52.02
Head of Household	Yes	46.27	52.17	95.38	62.64
	No	53.73	47.83	4.62	37.36
Income Category	Very poor	2.41	6.02	6.60	4.72
	Poor	33.01	18.39	30.03	27.83
	Comfortable	56.14	57.19	56.77	56.64
	Well-off	7.95	14.38	4.62	8.85
	Very well-off	0.48	4.01	1.98	1.97
Education	No schooling	20.96	21.07	38.28	26.16
	Primary school	25.78	32.44	45.21	33.53
	Secondary school	31.33	21.40	7.92	21.44
	High school	17.59	14.05	7.59	13.57
	Vocational training	0.96	1.67	0.00	0.88
	University	2.65	9.03	0.99	4.03
	Postgraduates	0.72	0.33	0.00	0.39
			Mean		
Age		37.76	41.45	48.29	41.99
Years engaged in farming		21.59	21.23	27.30	23.18
Distance to nearest market (km)		4.32	8.36	6.97	6.30

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