ESSAYS ON VULNERABILITY TO CLIMATE CHANGE AND CHILD MALNUTRITION IN SOUTHEAST ASIA

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ZUSAMMENFASSUNG

Südostasien gehört zu den Regionen der Welt, die am stärksten von negativen Effekten des Klimawandels betroffen sind. Extreme Wettersituationen wie Dürren, Überflutungen, außergewöhnliche Hitze und Regen sowie tropische Stürme treten häufiger und intensiver auf. Gleichzeitig ist die Region abhängig von der Landwirtschaft, wodurch die Lebensgrundlagen der Menschen in besonderem Maße von klimatischen Risiken betroffen sind. Unter diesen Umständen sind die Wahrnehmung des Klimawandels und die Anpassungsentscheidungen der Landwirte wichtige Aspekte für das Design von Anpassungsstrategien auf Seiten der Politik und landwirtschaftlicher Beratungsdienste. Des Weiteren ist es wichtig, die effiziente Allokation der eingeschränkt zur Verfügung stehenden Ressourcen für den Anbau von Nutzpflanzen und Nutztieren vor dem Hintergrund der klimatischen Risiken zu untersuchen.

In der vergangenen Dekade ist das Wirtschaftswachstum und die strukturelle Transformation in Südostasien erheblich vorrangeschritten. Dadurch sind Millionen von Menschen aus der Armut entkommen. Allerdings ist die Armut, gemessen als der Anteil der Bevölkerung, die mit weniger als $1.25 auskommen muss, in der Region immer noch hoch. Unglücklicherweise sind die Armen am anfälligsten für den Klimawandel. Neben klimatischen Risiken ist die Unterernährung von Kindern weiterhin eine Herausforderung für die Entwicklung Südostasiens. Die Reduzierung der finanziellen Armut alleine führt nicht zwangsläufig zu geringeren Unterernährungsraten. Weitere Erkenntnisse zu der Korrelation zwischen finanzieller Armut und dem Ernährungsstatus von Kindern kann durch einen Vergleich von ländlichen und stadtnahen Gegenden gewonnen werden.

Die vorliegende Dissertation besteht aus drei Essays zu den oben beschriebenen Themenbereichen und hat zum Ziel, die klimabezogenen Risiken mit denen die Landwirte konfrontiert sind, die Wahrnehmung von und Anpassung an den Klimawandel, die optimale Ressourcenzuteilung sowie den Ernährungsstatus von Kindern vor dem Hintergrund der risikoreichen klimatischen Bedingungen in Südostasien zu analysieren. Konkret beschäftigen sich die Essays mit den folgenden Forschungszielen: (i) Analyse der Wahrnehmung des Klimawandels und Anpassung an den Klimawandel durch Landwirte in Thailand und Vietnam; (ii) Identifikation effizienter Anpassungen der landwirtschaftlichen Tätigkeiten an klimabezogene Risiken von landwirtschaftlichen Haushalten in der Provinz Thua Thien Hue in Vietnam; und (iii) vergleichende Analyse der Korrelation zwischen finanzieller Armut und

der Ernährungssicherheit von Kindern in der ländlichen und stadtnahen Räumen in den drei benachbarten Ländern Thailand, Laos und Vietnam.

Die Datenanalyse, die im Rahmen dieser Dissertation genutzt wird, basiert auf einem fünfjährigen Paneldatensatz aus 4400 nichtstädtischen Haushalten in Thailand und Vietnam. Die Daten wurden in den Jahren 2007, 2008, 2010, 2011 und 2013 in drei Provinzen im Nordosten Thailands und in drei vietnamesischen Provinzen, welche im Norden, an der zentralen Küste und im zentralen Hochland von Vietnam gelegen sind, erhoben. Es ist anzunehmen, dass die ausgesuchten Provinzen über eine weniger entwickelte Infrastruktur verfügen und die Bevölkerung in besonderem Maße von Armut bedroht ist. Die Erhebungsinstrumente bestehen aus einem Haushaltsfragebogen, welcher Fragen zu den Lebensumständen der Haushalte beinhaltet, und einem Dorffragebogen, welcher Fragen zur physischen und sozialen Infrastruktur innerhalb eines Dorfes umfasst. Zusätzlich werden im dritten Essay neben dem Hauptdatensatz Daten aus einem Add-on Projekt aus der Provinz Savannakhet in Laos genutzt, welche die Jahre 2013 und 2014 umfassen.

Der **erste Essay** untersucht, wie landwirtschaftliche Haushalte den Klimawandel wahrnehmen und wie sie sich an den Klimawandel anpassen. Zunächst wird im Essay dargestellt, welche klimabezogenen Schocks landwirtschaftliche Haushalte erleben, ob die Landwirte eine Veränderung in den langzeitklimatischen Bedingungen wahrnehmen und welche Indikatoren Landwirte nutzen, um den Klimawandel zu beschreiben. Dieser Teil der Auswertung erfolgt mittels einer deskriptiven Analyse. Anschließend wird in diesem Essay analysiert, welches die Determinanten für die Wahrnehmung der Landwirte in Bezug auf den Klimawandel sind und welche Faktoren ihre Entscheidung, ihre Produktion anzupassen, beeinflusst. Diese Analyse wird durch ein Heckman Selektionsmodel durchgeführt. Außerdem werden die Effekte, welche mit den verschiedenen Anpassungsentscheidungen zusammenhängen, mit Hilfe eines Multinominalen Logit-Modells analysiert.

Die Resultate zeigen, dass in beiden Ländern die Mehrheit der landwirtschaftlichen Haushalte klimabezogene Schocks erlebt, die Haushalte den Klimawandel erkennen und eine eigene Art haben, dieses Phänomen zu beschreiben. Des Weiteren wird deutlich, dass die Wahrnehmung des Klimawandels durch die Landwirte durch die klimabezogenen Schocks verstärkt wird. In Vietnam ist die Wahrnehmung darüber hinaus auch durch Charakteristika der Befragten und Ortsvariablen geprägt. Die Faktoren, welche die Anpassungsmethoden treiben, unterschieden sich je nach Anwendung, Provinz und Land. Die Faktoren bestehen auch aus den

Charakteristika der Befragten und des Haushaltsvorstands. Die drei klimaspezifischen Variablen, die Wahrnehmung von Niederschlags, Temperatur und Wind, sind die vielleicht wichtigsten Faktoren, welche die spezifischen Anpassungsmethoden erklären. Diese Resultate können wichtige Information für politische Entscheidungsträger und landwirtschaftliche Beratungsdienste sein, welche ihr Verständnis für die Wahrnehmung des Klimawandels durch die Landwirte und die damit einhergehenden Einschränkungen, die wiederum die Landwirte davon abhalten, mehr und bessere Anpassungsmaßnahmen vorzunehmen, verbessern sollen.

Der **zweite Essay** quantifiziert die Effekte von klimabezogenen Schocks durch die Schätzung einer Cobb-Douglas Produktionsfunktion für die Hauptnutzpflanzen im Flach- und Hochland der Provinz Thua Thien Hue in Vietnam mittels der Ordinary Least Squares (OLS) Schätzung. Die Koeffizienten der Risikoindikatoren aus der Cobb-Douglas Funktion werden dann als Input für das mathematische Target MOTAD Model genutzt, um die effiziente Anpassungen der landwirtschaftlichen Tätigkeiten an klimabezogenen Risiken zu ermitteln. Die Resultate zeigen, dass Überflutungen, Schädlinge, Dürren, Kälteperioden und Tierkrankheiten die größten klimatischen Risiken für landwirtschaftliche Haushalte in der Provinz darstellen. Die extremen klimatischen Ereignisse haben einen negativen Einfluss auf die Produktion von Nutzpflanzen und Nutztieren. Je nach Nutzpflanze sind die Landwirte unterschiedliche stark von den jeweiligen Risiken betroffen.

Die Resultate aus der mathematischen Modellierung zeigen, dass risikoeffiziente Pläne sich deutlich von der tatsächlichen Planung der Landwirte unterscheiden. Dies trifft insbesondere für landwirtschaftliche Betriebe im Flachland zu. Konkret bedeutet dies, dass sich die Einkommenssicherheit der Landwirte im Flachland hauptsächlich auf Reis- und Maisanbau ohne Nutztiere stützt, während die Einkommenssicherheit für Landwirte im Hochland auf Reis-, Mais- und Kassavaanbau sowie Nutztiere basiert. Nutztiere gehören nicht zum optimalen Portfolio für Landwirte im Flachland, da dies mit hohen „reduzierten Kosten“ und großer Einkommensvariabilität einhergeht. Aufgrund des Zielkonflikts zwischen Einkommenssicherheit und dem durch Nutztiere potenziell erreichbaren Einkommenslevel für Landwirte im Flachland, verhalten sich die Landwirte möglicherweise mit einer geringeren Risikoaversion, wie vom Modell angenommen, um eine höhere Einkommenschance zu erzielen. Die Resultate aus der mathematischen Modellierung offenbaren außerdem, dass der Faktor Arbeit im Überschuss vorhanden ist, während die

Faktoren Land und Bargeld nur eingeschränkt zur Verfügung stehen. Insgesamt zeigen die Ergebnisse, dass die Implementierung von Risikomanagement-Tools, die Schaffung von mehreren Beschäftigungen außerhalb des landwirtschaftlichen Betriebs und/oder Selbstständigkeit außerhalb der Landwirtschaft, freizügigere Mietflächenmärkte und besserer veterinärer Services Landwirte dabei unterstützen könnten, besser mit den negativen Effekten des Klimas umzugehen.

Neben den klimatischen Risiken und dem Klimawandel bildet die Mangelernährung von Kindern eine weitere große Herausforderung für die Entwicklung in Südostasien. Dieses Entwicklungsproblem wird im **dritten Essay** diskutiert. In diesem Essay wird insbesondere untersucht, ob in Thailand, Laos und Vietnam ein Rückgang der finanziellen Armut automatisch mit einer Reduktion der Mangelernährung von Kindern unter fünf Jahren einhergeht. Des Weiteren wird in diesem Essay untersucht, inwieweit in diesen Ländern Unterschiede zwischen stadtnahen und ländlichen Gebieten hinsichtlich der Linderung von Armut und Mangelernährung bestehen. Die Analyse erfolgt anhand deskriptiver Statistiken und der Ordinary Least Squares (OLS) Schätzung sowie eines Fixed-Effects-Modells auf Bezirkskebene. Die Ergebnisse deuten darauf hin, dass die Ernährung von Kindern trotz aller Erfolge bei der Armutsminderung sowohl in stadtnahen als auch in ländlichen Gebieten in all diesen Ländern ein Problem ist. Bei den zwei Hauptindikatoren für die Ernährung, nämlich Untergewicht und Wachstumsstörung, stellt der letztere das größere Problem dar. In allen drei Ländern tritt die „extreme“ Unterernährung häufiger auf als die „moderate“.

Eine Haupterkenntnis aus der Analyse ist es, dass unabhängig vom Einkommen, Kinder aus ländlichen Gegenden mehr von Wachstumsstörung und Untergewicht betroffen sind als Kinder aus stadtnahen Gegenden. Sowohl in ländlichen als auch in stadtnahen Gegenden ist die Gesundheit der Kinder eine Hauptkomponente der Ernährungssituation von Kindern. In stadtnahen Gegenden spielen darüber hinaus das soziale Netzwerk sowie das Netzwerk der erweiterten Familie eine wichtige Rolle. In ländlichen Gegenden ist vorrangig die Ernährungssituation der Mutter maßgeblich für den Gesundheitszustand ihres Kindes. Insgesamt zeigen die Resultate, dass die Ernährungslücken zwischen ländlichen und stadtnahen Gebieten überwunden werden müssen. Allerdings sollten hierfür verschiedene Strategien genutzt werden, um die Ernährungssituation der Kinder zu verbessern. Unter anderem umfassen diese Strategien kosteneffektive Angebote zur Kinderbetreuung in

stadtnahen Gegenden sowie die Entwicklung von Konzepten für medizinische Einrichtungen in ländlichen Gebieten.

Stichworte: Wahrnehmung, Anpassung, Klimawandel, klimabezogene Risiken, mathematische Modellierung, optimale Pläne, Mangelernährung von Kindern, stadtnah, ländlich, Südostasien

ABSTRACT

Southeast Asia is considered as one of the most vulnerable regions to the downside effects of climate change. Extreme weather events such as droughts, floods, unusual heat and rainfall, tropical cyclones have been more frequent and intense in this region. In the meantime, the region's heavy reliance on agriculture for local residents' livelihood makes it highly vulnerable to these climate-related risks. Under such circumstances, the perceptions of climate change and adaptation choices made by farmers are important considerations in the design of adaptation strategies by policy makers and agricultural extension services. Furthermore, the exploration for an efficient allocation of farm's bounded resources among crop and livestock production activities under climate risks is also of a great importance.

Southeast Asia has witnessed a rapid economic growth and structural transformation over the last decades. This has helped millions of people move out of poverty. Nevertheless, poverty incidence reflected by the proportion of population living under the $1.25 remains high in the region and unfortunately, the poor are the most vulnerable to climate change. Beside climate risks, child malnutrition is another development challenge confronting Southeast Asia. As a matter of fact, the reduction of monetary poverty does not necessarily translate into a decrease in the malnutrition rates. Insights into the correlation between monetary poverty and child nutritional outcomes might be gained through a comparison between rural and peri-urban areas.

In this context, the thesis comprising three essays aims to examine the climate-related risks confronting farmers, perceptions of and adaptation to changing climate, optimal resource allocation and child nutritional outcomes under such risky climate in Southeast Asia. The specific research objectives are: (i) to investigate the farmers' perceptions of and adaptations to climate change in Thailand and Vietnam; (ii) to identify the farmer's efficient adjustments of production activities to climate-related risks in Thua Thien Hue province in Vietnam and (iii) to examine the relationship between monetary poverty and child nutritional outcomes with rural versus peri-urban context in three neighboring countries - Thailand, Lao PDR and Vietnam.

To do so, the thesis draws on the five-year panel data set of around 4,400 non-urban households in Thailand and Vietnam. The surveys were conducted in 2007, 2008, 2010, 2011 and 2013 in three provinces in the Northeastern Thailand and three provinces in the North

Central Coast and Central Highlands of Vietnam. The targeted provinces are assumed to have less developed infrastructural conditions and their inhabitants are likely to be vulnerable to poverty. The survey instruments comprise of household questionnaire including questions on household livelihoods and village questionnaire asking physical and social infrastructure of the community. Beside this main dataset, data from an add-on project in Savannakhet province, Lao PDR in 2013 and 2014 are additionally used in the third essay.

The **first essay** explores the farmers' perceptions of and adaptations to climate change of rural households in Thailand and Vietnam. The essay, first, investigates the climate-related shocks that farm households experienced, whether they do perceive a change in the longer term climate conditions and which indicators they use to describe climate change. This objective is tackled by means of a descriptive analysis. Second, the essay examines the determinants of the farmers' perceptions of climate change and their decision to adjust the agricultural production by means of Heckman selection model. Last, the drivers of different adaptation measures taken by farmers are explored by Multinomial Logit model.

Results show that the majority of farm households in both countries have experienced climate-related shocks, do recognize climate change and have their own way of describing this phenomenon. Also, the results point out that farmers' perceptions of climate change are engraved by climate related shocks and in Vietnam are additionally shaped by respondent's characteristics and location variables. Finally, the factors that drive adaption measures differ among practices, provinces and countries. They are also found in characteristics of respondent and household head. The perhaps most important factors in explaining specific adaptation measures are the three specific climate variables namely the perceptions of rainfall, temperatures and wind. These results can provide important information to policy makers and agricultural extension services who should improve their understanding of the farmers' interpretation of climate change and the constraints that have so far prevented them from undertaking more and better adaption measures.

The effects of climate-related shocks are quantified in the **second essay** through the estimation of Cobb-Douglas production function by ordinary least squares (OLS) for major crops in the lowland and upland areas of Thua Thien Hue province in Vietnam. The coefficients of risk dummies in the regression of Cobb-Douglas function are then incorporated in the Target MOTAD mathematical model to identify the farmer's efficient adjustments of crops and livestock production to climatic risks. Findings reveal that flooding, pestilence, drought, coldness and livestock diseases were the most common climate-related risks confronting the farm households in this province. These climatic extreme events negatively affected crop production as well as livestock production. The vulnerability to risks was, however, different among crops.

The results of the mathematical programming show that the risk efficient plans differ from the actual farmer's plan especially in case of the lowland farm. Specifically, the farming pattern which ensures income safety for the lowland farm comprises of rice and corn cropping without livestock while rice, corn, cassava and livestock for the upland farm. The exclusion of livestock out of lowland farm's optimal plan is due to the high "reduced cost" and large income variability. Since there is a trade-off between income safety and income level in livestock production found in the lowland farm, farmers maybe behave with lower levels of risk aversion as assumed by the model in order to have a chance for a higher income. The mathematical results also disclose remarkably abundant labor but constraints in land and cash. Findings overall suggest that implementation of risk management tools; generation of more off-farm and/or non-farm self-employment; more liberated rental land markets and better veterinary services will help farmers to better cope with negative climate effects.

Besides climate risks and climate change, child malnutrition is another big development challenge confronting Southeast Asia. This development issue is discussed in the **third essay**. In particular, this essay examines whether a decline in monetary poverty automatically results in malnutrition reduction in children under age five in Thailand, Lao PDR and Vietnam. It also investigates the peri-urban and rural differences in poverty and malnutrition alleviation in these countries. The analysis is done by means of descriptive statistics and ordinary least squares as well as a district level fixed-effects regression. The results imply that child nutrition remains a problem despite achievements in poverty mitigation in both peri-urban and rural areas in all these countries. Between the two major nutrition outcome indicators, namely underweight and stunting, the latter is the bigger problem. The "severe" undernutrition is even higher than the "moderate" in all three countries.

A key insight is that irrespective of income levels rural children are more stunted and underweight than their urban counterparts. Child health primarily drives child nutritional outcomes in both peri-urban and rural areas. This implies that apart from nutrition access to medical facilities for children are vital for development. Moreover, in peri-urban setting,

social and extended family networks play a critical role in childcare; while in the rural areas mother`s nutritional outcomes largely determine child health. Overall, findings suggest that the rural and peri-urban child nutritional gaps need to be bridged. However, different strategies for peri-urban and rural should be adopted to improve child nutritional outcomes. Among others, cost-effective childcare services should be established in peri-urban areas and schemes need to be developed to build medical facilities in rural areas.

Keywords: Perception, adaptation, climate change, climate-related risks, mathematical modeling, optimal plan, child malnutrition, peri-urban, rural, Southeast Asia

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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
BMI	Body-Mass-Index
FAO	Food and Agriculture Organization of the United Nations
FE	Fixed-effects
GAMS	General Algebraic Modeling System
GDP	Gross Domestic Product
GSO	General Statistics Office of Vietnam
Ha	Hectare
HFA	Height-For-Age
IIA	Independence of Irrelevant Alternatives
IPCC	Intergovernmental Panel on Climate Change
km	kilometer
LP	Linear Programming
LR	Likelihood Ratio
LU	Livestock Unit
MD	Man Day
MNL	Multinomial Logit Model
mm	millimeter
MOTAD	Minimization Of Total Absolute Deviations
OECD	The Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
PDR	People's Democratic Republic
PPP$	Purchasing Power Parity Dollar
RCRPH	Research Center for Rural Population and Health
SD	Standard Deviation
SSD	Second-Degree Stochastic Dominance
TVSEP	Thailand-Vietnam Socio-Economic Panel
UNICEF	United Nations International Children’s Emergency Fund
VIHEMA	Vietnam Health Environment Management Agency
WB	World Bank
WFA	Weight-For-Age
WHO	World Health Organization

Chapter 1 : INTRODUCTION

1.1. Research Background

Being considered as a global phenomenon, climate change has been occurring in Southeast Asia like in other parts of the world. According to records of Intergovernmental Panel on Climate Change (IPCC, 2007, 2014), temperature across the region has been increasing at a rate of 0.14°C to 0.20°C per decade since the 1960s. This has resulted in a rising number of hot days and warm nights, as well as a decrease in cooler weather. Regarding to precipitation, a downtrend of rainfall has been observed but with an increase of rainfall from extreme rain days by 10 mm per decade. Evidences also show an increase of sea levels between 01 mm to 03 mm per year, which is marginally greater than the global average. These climate changes and variabilities have led to more intense and frequent extreme weather events such as droughts, floods, tropical cyclones and probably climate-induced pests and diseases. These might explain why several countries of the region are ranked into the group with "very high chance of natural disasters" in the World Risk Report (2016).

Southeast Asia is considered as one of the most vulnerable to climate change region due to its unique characteristics. In particular, dense population of 563 million people and numerous economic activities concentrated along coastlines of around 173,251 km are highly exposed to the risk of rising sea levels. At the same time, the livelihoods of local inhabitants depend heavily on agricultural production and natural resources despite rapid structural transformation. Indeed, agriculture sector accounted for 43% of total employment in 2004 and 11% of GDP in 2006 of the region (ADB, 2009).

Over the last decades, Southeast Asia has witnessed a speedy economic growth. The region's average GDP grew at 5.5% annually compared to the world's rate of 2.9% in the period of 1990-2007. Similarly, the average GDP per capita of the region was much higher than that of the whole world, namely 3.6% compared to 1.5%. This spectacular economic performance has driven millions of people out of extreme poverty trap. Nevertheless, the poverty incidence remains substantially in this region. As of 2005, about 19% of Southeast Asian residents still lived with less than $1.25 per day and even nearly 45% of regional population lived under the $2 poverty line (ADB, 2009). In the community, the poorest people are unfortunately the most vulnerable to the harm caused by climate changes due to the lack of capability to recover from climatic hits.

Beside climate change, childhood nutritional status is another big development challenge faced by many Southeast Asian countries despite their efforts in reducing monetary poverty. According to the child malnutrition estimates in 2007 jointly made by the United Nations Children's Fund (UNICEF), World Bank Group and World Health Organisation (WHO), the child malnutrition prevalence is quite problematic in Southeast Asia. Specifically, 25.8% of children under five in this region are stunted, while 8.9% and 14.7% of the region's children under five are wasting and underweight, respectively.

In this regard, this thesis attempts to examine the vulnerability of Southeast Asia in the context of climate change. It assesses the impact of climate change on agricultural production and agricultural adjustment in response to changing climate. It also sheds light on child nutritional status in the region.

1.2. Research Objectives

The thesis focuses on the vulnerability of farm households to changing climate as well as the child nutritional outcomes under climate-related risks in Southeast Asia. That overall objective shall be achieved in three essays as follows:

In the **first essay,** the focus in on the farmers' perceptions of and adaptations to climate change in Thailand and Vietnam. As a matter of fact, scientific data have proved that climate change is affecting Southeast Asia as it does in many other regions of the world (IPCC, 2014). Following the literature (Deressa et al., 2008; Gbetibouo, 2009), it would be expected that in Southeast Asia farmers' perceptions of changing climate are in line with climatic data records. The objective of the first essay is hence to verify this hypothesis. In addition, these literatures also indicate that only a few farmers adjust their farming activities despite high awareness of climate changes. The essay thus additionally aims to explore the adaptations to changing climate in Southeast Asia. In detail, the essay addresses the following questions:

(i) What climate-related shocks did farm households experience, what observations did they make about changes in climate over time and what indicators they use to describe climate change?

(ii) What determines the farmers' perceptions of climate change and their decision to adjust agricultural production in response to the effects of perceived climate change?

(iii) What explains the choice of specific agricultural adaptation measures by farm households?

Answering these questions, the essay intends to provide important information for policy makers and agricultural extension workers to facilitate their understanding of the farmers' interpretation of climate change and their possible constraints to adaption.

The **second essay** focuses on farm households' optimal adjustment of agricultural activities to climatic risks. To deal with the optimizing farmer's income, mathematical programming comes into play. In this respect, the literature can be divided into two strands: one ignores risks such as the studies of Minh et al. (2007), Igwe and Onyenweaku (2013), Hosu and Mushunje (2013), Shreedhar et al. (2015); and the other incorporates risks in the programming, for example, the studies of Maleka (1993), Umoh (2008), Voelker et al. (2013). Since Thua Thien Hue province in Vietnam - the study area in this essay - is highly exposed to natural disaster risks, the latter approach is applied in this study. Specifically, the study follows the interdisciplinary modeling method (Keil et a., 2009) which combines mathematical programming with regression analysis to figure out the risk efficient farming pattern under climatic risks of famers in this province. In order to solve this task, this essay deals with two specific objectives as follows:

(i) To assess the vulnerability to climate-related risks of farm households in Thua Thien Hue province

(ii) To identify the optimal adjustment of agricultural activities to climatic risks of farm households in Thue Thien Hue province

By articulating the goals and constraints of typical farm, the mathematical programming offers an objective assessment in determining an optimal combination of farm enterprises in response to climate-related risks in the study area, which is useful for aggregate policy analysis (Hazell and Norton, 1986).

The **third essay** investigates the relationship between monetary poverty and nutritional outcomes of children under five in three neighboring Southeast Asian countries - Thailand, Lao PDR and Vietnam. Over the last decades, these three countries have developed rapidly although at different paces and have been successful in reducing monetary poverty. As shown by many literatures (Sen and Anand, 1997; Bourguignon and Chakravarty, 2003; Alkire and Foster, 2011; Ferreira, 2011) poverty is multi-dimensional and the correlation between reducing monetary poverty and non-monetary poverty measures is often low. Several empirical researches, among others are Baulch and Masset (2003), Haddad et al. (2003), Alderman et al. (2006), have claimed that weak correlation between monetary poverty and nutritional poverty. In other literature (for example Frankenberg et al., 1998; Garrett and Ruel, 1999; Smith et al., 2005; Fotso, 2007), it is found that urban children generally have a better nutritional status than their rural counterparts. This essay intends to build the literature gap in examining the relationship between monetary poverty and nutritional outcomes in three neighboring emerging countries but with different economic development level- Thailand, Lao PDR and Vietnam. Furthermore, the essay aims to investigate the potential rural and peri-urban differences in monetary and nutritional poverty among the three countries. The specific objectives of this essay are:

(i) To explore the monetary poverty by region

(ii) To examine the malnutrition of children under five years old by region

(iii) To investigate the correlation between monetary poverty and child nutritional outcomes

1.3. Methodologies

To achieve the above-mentioned research objectives, a number of theoretical and empirical methodologies are applied in the thesis. They are briefly described below:

In the **first essay,** farmers' perceptions of and adaptations to climate change are investigated. In this regards, the essay follows the argument of Weber (2010) which stated that people's perception of climate change are shaped by learnings from personal experience and by making use of statistical information. The relationship between risk perception and the adoption of risk management actions can be gained from “perception-action cycle” (Fuster, 2002) where people prepare themselves for outcomes in their lives which according to their perception are, more or less, likely to occur in the future. Tversky and Kahnemann (1992) showed people tend to weigh potential losses higher than potential gains. Different from technology adaptation, which mostly aims at increasing profits, adaptations to climate change are undertaken to reduce risks and to minimize future losses. It is therefore necessary that in the adoption model the farmers’ perception of climate change is incorporated (Maddison, 2007; Deressa et al., 2008; Gbetibouo, 2009). This essay follows this approach and models the factors that influence climate change perceptions and related adaptation measures by employing Heckman selection model (Heckman, 1979). In the first stage, perception of climate change is specified as the outcome variable. In the second stage, adaptation is the outcome variable for respondents who reported awareness of climate change. Accordingly, households in the second stage are non-randomly selected from the entire sample. Heckman model is therefore utilized to control for the potential selection bias. The essay further explores the farmer’s drivers for four major categories of adaptation measures by means of a multinomial logit model (MNL). The estimations of both Heckman and MNL model are conducted in Stata 13.1

In the **second essay**, risk efficient farming patterns of small-scaled famers under climate-related risks are explored. The analysis is based on the concept of typical farm for each agro-ecological region. Typical farm must be representative of what a group of farmers are doing. The typical farm in this essay is established following a statistical approach. In order to minimize the possible aggregation bias, total farms are classified into homogenous groups. The classification is based on three rules of Hazell and Norton (1986) including: (i) similar proportions in resource endowments, often implying similar land-to-labor ratios; (ii) similar yields which usually means the analogous condition of soil, climate, irrigation and topography; (iii) similar technologies meaning the same predominant crops/livestock and the similar technologies used in production. Parameters for the typical farms are then constructed based on the mean values from selected sample excluding 5% outliers.

The investigation of an optimal resource allocation of typical farm under natural risks is then executed by means of interdisciplinary modelling approach, which combines mathematical programming with regression analysis (Keil et al., 2009). Specifically, in the first stage the effects of climate-related events on crop yields are estimated using Cobb-Douglas production function. The estimation of Cobb-Douglas production functions will be executed by OLS with district fixed-effects on the whole sample instead of selected households in order to get a larger number of observations. This step is conducted in Stata 14.2. In the second step, the gross margins of different crops in each state of nature, which are built up based on the mean and the coefficients of climatic dummies in the regression of Cobb-Douglas production functions will be incorporated in the mathematical Target MOTAD model. This model is in accordance with safety-first principle specifying that famers wish to maximize expected gross margin but at the same time are concerned about returns falling below a critical target. Target MOTAD model, which is composed of objective function and a set of constraints is then solved in GAMS 25.0.2.

The **third essay** investigates the link between monetary poverty and nutritional outcomes of children under five and explores the differentials between rural and peri-urban areas. The essay uses the two common anthropometric indices for accessing the nutritional status of children, namely height-for-age (HFA) and weight-for-age (WFA). These indicators are interpreted based on the Z-scores, which define anthropometric value as a number of standard deviations below or above the reference mean or median value of the World Health Organization reference population. The prevalence of undernutrition is determined by the cut-off of <-2 SD. A Z-score cut-off point between -3 SD and -2 SD are classified as moderate undernutrition and less than -3 SD as severe undernutrition (WHO, 2016).

This essay follows the UNICEF (Ruel, 2008; UNICEF, 2013) framework to examine the drivers of malnutrition. According to the framework, the nutritional outcomes of children are determined by a set of immediate, underlying, and basic causes relating to biological, behavioral, and social aspects. Empirically, the essay uses a reduced form nutritional function derived from the household production function to determine the nutritional outcomes of children under five (Glewwe et al., 2004; Alderman et al., 2006; Kabubo-Mariara et al., 2009; Waibel and Hohfeld, 2016). Since endogeneity is not detected, the estimation of determinants is done with ordinary least squares (OLS) and district level fixed-effects in Stata 13.1. The regression is run separately for rural and peri-urban in order to investigate the potential differentials between these two regions.

1.4. Data

The data used in this thesis mainly originate from a research project called "Thailand-Vietnam Socio-Economic Panel" (TVSEP)[1]. This panel data set of around 2,200 households in three provinces in each country Thailand and Vietnam was collected in 2007, 2008, 2010 and 2013. In Thailand, the provinces are Buri Ram, Nakhon Phanom and Ubon Ratchathani located in the Northeastern region of the country. In Vietnam, the provinces are Ha Tinh and Thua Thien Hue located in the North Central Coast region and Dak Lak situated in the Central Highlands (red highlighted parts of Figure 1.1). In 2011, the survey was conducted additionally in two provinces: Thua Thien Hue and Buri Ram. All six provinces are dominantly agricultural areas albeit with a large degree of heterogeneity in development potential. The provinces are bordering neighboring Laos and/or Cambodia. The purposive choice of the provinces in line with the overall goal of the project was motivated by the assumption that people in the non-urban and geographically remote regions are more vulnerable than people in urban and central regions (Waibel et al., 2013).

A three-stage random stratified sampling design method was used. The heterogeneity of agro-ecological and economic conditions of the survey areas is considered in the stratification. Accordingly, each province in Thailand is regarded as one stratum due to its high homogeneity. Differently, in Vietnam three strata were defined, namely rice plain, coastal area and mountainous area. In the first stage, sub-districts in Thailand and communes in Vietnam as the primary sampling unit were selected with probability proportional to the population size. In the second stage, two villages were randomly chosen from each sampled commune with the probability proportional to the size of the population. In the third stage, 10 households from each sampled village were selected systematically from a list of households ordered by household size with equal selection probability (Hardeweg et al., 2013). The attrition rate was quite low, approximately between 2% and 3% per year.

[1] See https://www.tvsep.de

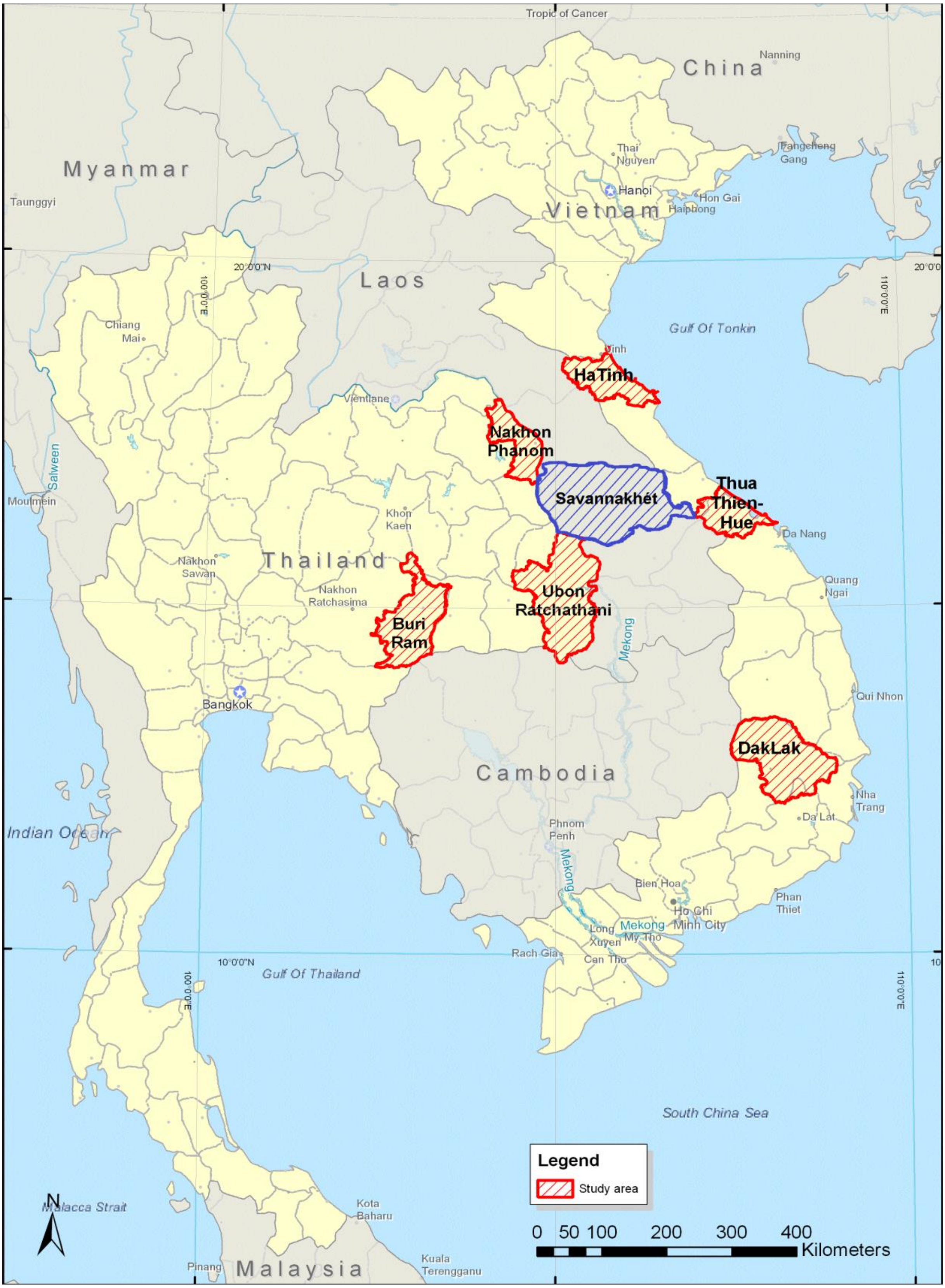

Figure 1.1: Study areas

Source: Hardeweg et al., (2013), modified

The **first essay** focuses on farmer's perception of and adaptations to climate change. The sample is therefore restricted to farm households, specifically 1,529 in three provinces in Vietnam and 1,361 in three provinces in Thailand. Since the special module on climate change was not available in the questionnaire before 2013, the data used in this essay mostly come from the 2013 survey. Beside data on climate change, the essay also makes use of data on climate risks, climate shocks, household demographic and socio-economic characteristics, household income, farm management practices and physical infrastructure of the village. In order to get a glance on the changes in farm management practices over time, data of the first wave 2007 is additionally included.

In the **second essay**, the optimal adjustment of farming pattern of farmers under climate-related risks is studied. Hence, the essay constrains the study area to Thua Thien Hue province (Vietnam), which is highly prone to natural hazards. In this regard, the five year balanced panel data 2007-2013 are utilized. In particular, the essay focuses on the information on crop and livestock production, income compositions, land, labor endowment. Climate-related risks and shocks are the other important data for this essay. Due to the diverse topography among regions in Thua Thien Hue province, the major farming activities in these regions are different. Specifically, in the upland and the lowland areas the predominant activity is agricultural production whereas in the coastal it is aquaculture. Since the study explores only agriculture, the study areas are constrained to the lowland and the upland with the number of households of 219 and 212, respectively.

The **third essay** includes three provinces, namely Ubon Ratchathani in Thailand, Savannakhet in Lao PDR and Thua Thien Hue in Vietnam. All three provinces are geographically close and can be treated as an economic corridor in the Greater Mekong Sub-region (ADB, 2010). So beside data from TVSEP, data from an add-on research project on Food Security in Savannakhet in Lao PDR (blue highlighted part of Figure 1.1) are added in this essay. Different from the sampling in Thailand and Vietnam, sample in Savannakhet was collected based on two-stage method though it was also first stratified due to the diverse topography. Three strata of Savannakhet province from the west to the east are Mekong, Lowland and Upland. In the absence of a well-defined administrative structure in Laos, villages were used as the primary sampling unit. In the first stage, villages within the strata region were sampled. The probability of a village being chosen was proportional to its size. In the second stage the cluster size of 15 households per village in the Mekong and lowland regions were applied while in the mountainous regions it is 10 households per village. Households were then selected randomly from the village lists. The surveys in Savannakhet were conducted in 2013 and 2014. To have the similar reference period, the 2011 and 2013 data of Ubon Ratchathani and Thua Thien Hue are chosen. Since the essay focuses only on children under five, database includes 1,105 households with 1345 children under five from these three provinces were used. Information on nutrition outcomes of children under five including age, gender, height, weight as well as health conditions are of great importance in the essay. The individual level data for mother, household level data on consumption, domestic infrastructure, village level data on physical and infrastructure constitute other part of the database.

1.5. Results

In the **first essay**, the descriptive results show that the majority of farm households in both countries have experienced recent climate-related shocks and the vast majority does perceive that climate has changed. Comparing farmer observations with existing literatures (Boonyawat and Chiwanno, 2007; Cuong, 2008; Jesdapipat, 2008, ADB, 2009) supports the notion that their subjective perceptions match scientific data. Results also point out that farmers have their own way of describing the climate change related phenomenon. Furthermore, farmers reported adaptation measures which they are planning to undertake or have already undertaken in response to climate change. However, the share of households reported adaptations is much smaller than the share of households which perceived changing climate.

The econometric results indicate that perception can be reasonable linked to farmer's decision to undertake adaptation measures. The model for Vietnam shows that perceptions of climate changes are shaped by the respondent's characteristics, location variables and recent climate related shocks. Unfortunately, results for the Thailand model are less convincing. However, the climate-related shock variable is significant and consistent with the results in Vietnam. The adaptation likelihood of Vietnamese households is explained by characteristics of household head and household and location dummies. Similar to the selection equation, the results in outcome equation for Thailand are also less convincing than those for Vietnam. These could be attributed to the fact that Vietnam has a higher chance of natural disasters than Thailand (World Risk Report, 2016).

The econometric results also show that driver for specific climate change related adaption measures differ among practices, provinces and countries. They are to be found in the characteristics of the respondent and the household head whenever there is a difference between the two. The perhaps most important factor in explaining specific adaptation measures are the three specific climate variables namely rainfall, temperatures and wind which are all significantly correlated with tree plantation. While for the other adaptation measures such as crop diversification, varietal change, etc. factors other than climate change may be more important, the clearest connection is found with trees.

Results about climate-related risks faced by farmers are further illustrated in the **second essay**. Specifically, descriptive results point out that flooding, pests/livestock diseases, drought and coldness are the most common climate-related shocks experienced by lowland and upland farms in Thua Thien Hue province where the latter subjectively report higher level of impact severity than the former. The regression results, however, do not objectively reveal any evidence of regional differential in the impact of climate-related events on crop yields. Climatic extreme events, as expected, negatively affect crop production but the vulnerability to these risks is different among crops. Specifically, rice yield seems to be hit by more types of risks but with lower level of severity while corn and peanut yields are more heavily affected once extreme coldness occurred. The occurrence of livestock disease makes gross margins of livestock vary much over years.

The results of the mathematical programming show that the farming pattern which ensures income safety consists of rice and corn cropping without livestock for the lowland farm while rice, corn, cassava and livestock for the upland farm. These risk efficient plans differ from the observed farmer's plans especially in the case of the lowland areas where farmers keep chicken and pigs beside crop activities. Another important finding from the mathematical programming is that regardless of lowland or upland, of actual production pattern or model solution pattern, agricultural labor is considerably underemployed especial during the off-farm seasons. Sensitivity analysis shows that the lowland farm households could increase their income through enlarging land for cropping rice and corn besides taking additional off-farm occupation. The land rental could be then financed by additional off-farm income or borrowings. Upland farm might additionally expand stall capacity for more pigs and chicken.

Results about child malnutrition and poverty are depicted in the **third essay**. Particularly, descriptive statistics reveal the perfect stochastic dominance in terms of monetary poverty among three provinces, Ubon Ratchathaini in Thailand, Thua Thien Hue in Vietnam and Savannakhet in Lao PDR with poverty highest in Savannakhet and lowest in Ubon Ratchathani. Ubon Ratchathini is quite homogenous and the consumption levels are similar among districts in this province. In contrast, big gaps between peri-urban and rural areas in both Thua Thien Hue and Savannakhet are found.

Concerning child malnutrition issue, results demonstrate that the undernutrition rates are the lowest in Ubon Ratchathani though all three provinces are characterised with very high prevalence of stunting. Savannakhet and Thua Thien Hue are classified with high prevalence of underweight. The comparison between the peri-urban versus rural areas points out that the peri-urban children are significantly less underweight than their rural counterpart but not significantly less stunted. Further investigation into the severity of child malnutrition reveals that regardless of malnutrition indicators – underweight or stunting, and areas- peri-urban or rural; the severe undernutrition rates are much higher than the moderate undernutrition rates (except the underweight in the peri-urban). The gap is extremely large in stunting, especially in the rural area. The peri-urban versus rural differentials accrue from severe undernutrition. Another important finding is that the weight-for-age gaps between peri-urban and rural are smaller than the consumption gaps between the two regions.

The regression results indicate that although all the first three consumption quintiles in both rural and peri-urban areas spend significantly less on food expenses compared to the highest quintile, the rural children are significantly more stunted and underweight than peri-urban children irrespective of household consumption levels. Child nutritional outcomes in the study areas appear to vary much by age of the child. The major determinants of outcomes both in rural and peri-urban areas include child health status and mother's nutritional status in terms of height although the magnitudes of their impacts are quite different across areas. The results also reveal two differences in the nature of determinants between rural and peri-urban areas. Firstly, aggregate household consumption has a greater effect on the child nutritional status in the rural areas than in the peri-urban area. Second, the migration of household members affects nutritional status of children in the peri-urban but not in rural areas.

1.6. Conclusions and Policy Implications

Results from the **first essay** lead to the conclusion that farmers in Southeast Asia do perceive changes in climate. However, farmers have their own way of describing the climate change related phenomenon. Farmers' perceptions of changes in rainfall, temperatures and wind do affect their decision to take different adaptation measures especially planting trees. Another major finding that despite the high share of households who perceived changing climate only the minority of them undertake adaptation measures implies constraints preventing farmers from adaptation. These findings suggest that policy makers and agricultural extension services should improve their understanding of the farmers' interpretation of climate change and the constraints that have so far prevented them from undertaking more and better adaptation measures. Further studies should take a more in-depth look at those constraints and provide a detailed assessment of the costs and benefits of farmer-based adaption measures.

Descriptive and regression results in the **second essay** prove that agricultural production in Thua Thien Hue province is negatively affected by climate-related extreme events. However, the vulnerability to these risks is different among crops. Results also suggest that the upland farm households may have less ability and capability to cope with climate-related shocks and thus are more vulnerable to climatic risks. The results of the mathematical programming imply a trade-off between safe income and high income in livestock production in the lowland areas in this province. This means that in expectation of a better income, farmers in reality may behave with lower levels of risk aversion as assumed. Overall, this essay recommends appropriate coping strategies to lessen the negative effect of climate-related risks. Production risks and their negative impact could be reduced if there existed an efficient risk management tool such as an agricultural insurance program. Additionally, the implementation of a routine vaccination schedule in livestock to prevent diseases is also highly recommended. These measures could assure farm households farming patterns which yield higher and safer income. The findings also recommend that support for abundant agricultural labor to find suitable seasonal off-farm jobs or for farms to establish non-farm self-employment should be provided. In order to relax land and cash constraints for farms, liberated rental land markets should be promoted by land law and access to credit provided by official lenders should be supported.

The most important finding of the **third essay** is that malnutrition remains a problem in the growing economies of the three countries Thailand, Lao PDR and Vietnam in both peri-urban and rural areas although the situation in Thailand is better than that in the two neighboring countries. Another key insight is that irrespective of income levels rural children are more stunted and underweight than their urban. In addition, the stunting situation is even worse than the underweight. Child health primarily drives child nutritional outcomes in both peri-urban and rural areas. Results imply that even though a peri-urban child can be sick it is less likely to be stunted or underweight contrary to rural sick children who are also prone to be malnourished. This means apart from nutrition, access to medical facilities for children is vital for development. Overall, findings in this essay suggest that success in reducing monetary poverty does not lead to the same degree of success in reducing nutrition poverty. The rural and peri-urban nutritional gaps need to be bridged. To child nutritional outcomes, different strategies for peri-urban and rural should be adopted. Among others, cost-effective childcare services should be established in peri-urban areas and schemes need to be developed to build medical facilities in rural areas.

1.7. Thesis Outline

The thesis is organized in four chapter presenting three essays. The overview of earlier versions, presentation and publications of these essays are demonstrated in Table 1.1. The remainder of the thesis is structured as follows:

The next chapter presents the **first essay** on “Farmers’ Perceptions of and Adaptations to Climate Change in Southeast Asia: The Case Study from Thailand and Vietnam”. Specifically, section 2.1 introduces the vulnerability of farmers in Southeast Asia to climate change. Section 2.2 explicates the theoretical background for the determinants of individual climate change perceptions and adaptation behavior. Description of study areas and the data collection is followed in section 2.3. In section 2.4, the methodology used in this essay is described and section 2.5 reports descriptive results as background information for discussing the econometric results presented in section 2.6. Finally, in section 2.7, summary and policy conclusions are submitted.

Chapter 3 embodies the **second essay** titled “Efficient Adjustment of Agricultural Production to Climate Risks in Thua Thien Hue Province, Vietnam: A Target MOTAD Approach”. In particular, the study area and background are presented in section 3.1. It is followed by the description of mathematical modeling farm households using the concept of typical farms in section 3.2. Afterwards, section 3.3 defines the typical farm households in Thua Thien Hue province. Section 4 illustrates how the mathematical model is constructed. Model solutions are presented in section 3.5 and sensitivity analysis in section 6. Finally, section 3.7 summarizes and concludes the chapter with some policy implications.

Chapter 4 presents the third essay "Urbanization and Child Malnutrition: A Comparison of Three Countries in the Greater Mekong Sub-region". Concretely, section 4.1 explains why Thailand, Lao PDR and Vietnam are chosen for this study. Conceptual framework, which outlines the indicators measuring nutritional outcomes of children and the drivers of childhood nutrition and the methodology used in this study area presented in section 4.2. Details of study area and data collection procedure are discussed in section 4.3. Afterwards, section 4.4 reports the results and finally section 4.5 concludes the chapter with some policy recommendations.

Table 1.1: Overview of the essays constituting the dissertation

Essay No.	Title	Authors	Presented/Submitted/ Published
1	Farmers' Perceptions of and Adaptations to Climate Change in Southeast Asia: The Case Study from Thailand and Vietnam	H. Waibel, T. H. Pahlisch and M. Voelker	Published: In D. Zilberman, L. Lipper, N. McCarthy, S. Asfaw, and G. Branca, *Climate Smart Agriculture - Building Resilience to Climate Change (pp. 137-160).* Rome: Springer Earlier vesions presented at: 3rd Development Network Berlin - PhD Workshop. March 04, 2016, Berlin, Germany International Workshop on *Climate Change Debates, Policies and Economics – Vietnam and Beyond.* May 03-04, 2016, Roskilde, Denmark
2	Efficient Adjustment of Agricultural Production to Climate Risks in Thua Thien Hue Province, Vietnam: A Target MOTAD Approach	T. H. Pahlisch and H. Waibel	Presented at: Seminar International Doctoral Studies, November 11, 2017, Hannover, Germany
3	Urbanization and Child Malnutrition: A Comparison of Three Countries in the Greater Mekong Sub-region	T. H. Pahlisch, P. Parvathi and H. Waibel	Submitted to: *The Asian Development Review* Earlier vesion presented at: The 9th International Conference of the Asian Society of Agricultural Economists: *Transformation in Agricultural and Food Economy in Asia*. January 11-13, 2017, Bangkok, Thailand. TVSEP data use workshop; March 15, 2017, Hannover, Germany

Source: Own illustration

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Chapter 2 : FARMERS' PERCEPTIONS OF AND ADAPTATION TO CLIMATE CHANGE IN SOUTHEAST ASIA: THE CASE STUDY FROM THAILAND AND VIETNAM

Waibel, H., Pahlisch, T., & Voelker, M. (2018). Farmers' Perceptions of and Adaptations to Climate Change in Southeast Asisa: The Case Study from Thailand and Vietnam. In L. Lipper, N. McCarthy, D. Zilberman, S. Asfaw, & G. Branca, *Climate Smart Agriculuture Building Resilience to Climate Change* (pp. 137-160). Rome, Italy: Springer. Available at www.fao.org/3/a-i7931e.pdf.

Chapter 3 : EFFICIENT ADJUSTMENTS OF AGRICULTURAL PRODUCTION TO CLIMATE RISKS IN THUA THIEN HUE PROVINCE, VIETNAM: A TARGET MOTAD APPROACH

Abstract

Crop and livestock production in Thua Thien Hue province, Vietnam is highly exposed to climate-related risks. This chapter, therefore, aims to estimate the effects of climate risk on farming in this province. To achieve that objective, the concept of typical farm households for two agro-ecological regions namely the lowland and the upland area is applied. An interdisciplinary modeling approach, which combines the Cobb-Douglas regression analysis with the Target MOTAD mathematical programming model is used as a methodological tool. The estimates of Cobb-Douglas production function reveal that farms are most prone to pests and livestock diseases, flooding, storms and drought. The integrated Target MOTAD models generate an optimal plan, which differs from the observed farm portfolio which suggests that famers maybe behave with lower levels of risk aversion as assumed by the model. Results also disclose a redundancy of agricultural labor but constraints in land and cash. Findings suggest that implementation of risk management tools; generation of more off-farm and/or non-farm self-employment; more liberated rental land markets and better veterinary services will help farmers to better cope with negative climate effects.

Key words: Crops, livestock, climate-related risks, optimal plan, Cobb-Douglas production function, Target MOTAD model, Thua Thien Hue

3.1. Background

The province of Thua Thien Hue is located in the North Central Coast region of Vietnam. It has a surface area of around 4,902 km^2 and a population of about 1.154 million people (GSO, 2018) distributed between rural and urban areas. The province is marked by distinct ecological zones. It has a coastline of some 120 km along the South China Sea with lagoons and sand banks. This is followed by lowland plains with about 10% of the provincial area. Further inland, landscape becomes hilly, and towards the west there mountains with an altitude of up to 1,500 m above sea level part of the province, bordering Lao PDR. Upland areas cover 75% of the provincial landscape. Climatic conditions in the province show typical tropical monsoon conditions with rainy, dry and cool seasons. Thua Thien Hue is the province with a high level of annual precipitation, which is around 2,700 mm. However, variations in terms of precipitation level and the time of raining are remarkable among regions in this province. Specifically, in the coastal and lowland areas the rainy season takes place from September until December whereas in the upland area it is from May until December. The monthly average rainfall levels in the period 1991-2015 were highest of around 600 mm in November and lowest in February of roughly 50 mm both in the lowland and in the upland (Figure A3.1/A3.2). Depending on the year, the annual average rainfall may vary from 3,400 mm to more than 5,000 mm in the upland but only from 2,700 mm to 3,500 mm in the lowland and the coastal areas (Department of Science and Technology of Thua Thien Hue, 2004).

With some 300,000 ha forest in 2015 the province has the forest coverage of around 57%. The destroyed and fired forest (nearly 30,000 ha) has partly led to a large amount of vacant land or bare hills and mountains (28% of the total surface) (GSO, 2016). Due to the sloping terrain and large area of vacant land combining with the frequency of short but heavy rain events, floods and flash floods are very serious in the province causing sometimes severe economic and environmental consequences (Table A3.1/A3.2). Thua Thien Hue belongs to those areas in Vietnam, which are prone to high natural disaster risks and is hence particularly affected by climate change. On the climate change exposure scale which ranges from 0 to 1 the province is it at 0.73 (WHO, 2011). Typhoons and floods are the two dominant natural hazards in Thua Thien Hue. Floods occur often in the lowland areas with a frequency of 2-4 times a year. Typhoons are less frequent but cause more economic losses as they affect the entire province (Tran and Shaw, 2007; Le et al., 2013; Mendoza et al., 2014).

In general, weather observations in the region show that natural disasters tend to last longer and unpredictable than before (Tran and Shaw, 2007).

The economy of Thua Thien Hue is dominated by the service sector with tourism playing a major part. Over half of the provincial GDP in 2015 stemmed from the service sector followed by industry and construction with about 30% and agriculture forestry and aquaculture slightly over 11% (Figure A3.3). However, as it is the case for developing countries, the latter sector employs over 30% of the labor force (Figure A3.4). Land use in the province is dominated by forestland with over half the land or almost 300,000 ha. This is more than four times the area of agricultural crops (Figure A3.5). However, the extent of deforestation may well be underestimated dues to systematic underreporting. Rice is the major crop in Thua Thien Hue with area of about 40% of cropland and followed by cassava and maize. Aside from crops, livestock including over 2 million units of poultry, 200,000 heads of pigs and some 40,000 cattle and buffaloes are an important component of farming in the province (Table A3.3).

Farming in Thua Thien Hue is dependent on natural conditions and therefore different farming systems have developed in the lowland and upland areas of the province. Considering the change in economic and climatic conditions farmers are confronted with the challenge to find efficient ways adjusting to these conditions in order to avoid falling back into poverty. In this chapter a method to identify farm portfolios that present optimal adjustment measures to climate risks and climate change is presented. The analysis includes an assessment of the vulnerability of farm households in Thua Thien Hue province to climate-related risks and explores possibilities of an optimal reallocation of household resources to mitigate the downside effects of climate risks.

3.2. Mathematical Farm Modeling with Typical Farm Concept

Modeling farm households by mathematical programming is a tool to identify optimal farm plans and to systematically assess changes in farm organization including portfolios in crop and livestock production (Lin et al., 1974; Hazel and Norton, 1986). Farm models allow to take into account resources, activities, physical inputs and outputs as well as factor and product prices. Farm household plans can be identified that follow optimal resource allocation principles and maximize an objective function equivalent to the decision maker’s assumed utility. To apply this concept has two requirements: First to identify a suitable modeling and second to establish the empirical basis for modeling farm plans and their changes. Mathematical programming is a normative method consistent with the basic tenets of economic production theory tool that can be used to identify possible adjustment paths of farms who are confronted with a change in external conditions. Furthermore, the concept of typical farms can be used to combine and integrate different types of data in a consistent modeling framework.

In the literature, different examples of the application of mathematical programming exist. In some cases, this method is used to identify efficiency gaps in farmers' resource allocation. For example, Igwe and Onyenweaku (2013) developed a linear programming model for integrated crop livestock farms in Nigeria and showed significant differences between actual farming systems and optimal farm plans. Linear programming is also a suitable tool for analyzing the riskiness of farming. Other approach that has been popular in the literature is the Target MOTAD, i.e. the Minimization Of Total Absolute Deviation of output parameters like yield subject to a defined income target first introduced by Tauer (1983). An example of applying this approach is the study of Zimet and Spreen (1986) of a typical farm in North Florida. The authors showed that when risk was incorporated in the model, the optimal farm portfolio became more diverse. In a more recent application of Target MOTAD, Umoh (2008) examined optimal farm plans under risks in the floodplains farming in Akwa Ibon State, Nigeria and showed that farmers were inefficient in coping with production risk.

Mathematical programming can also be combined with other techniques such as regression analysis and stochastic simulation to identify risk-efficient crop management strategies. For example, Keil et al. (2009) analyzed vulnerability of smallholder farmers to ENSO-related drought in Indonesia. Specifically, the study aimed to assess the impact of El Niño on agricultural incomes of smallholder farmers in Central Sulawesi, Indonesia and to derive suitable crop management strategies to mitigate income reductions. The study found that El Niño-related drought led to drastic declines of crop yields and hence agricultural incomes of farmers but with remarkably different severities depending on farms' location, farming system and resource endowment. These results therefore suggest that drought-related crop management strategies must be tailored to specific farm households according to their characteristics. Another multi-method approach is found in study of Wineman and Crawford (2017) on farmers' crop choices under climate change in Zambia. Combining linear programming with climate prediction models, the two authors aimed to assess the impact of climate change on rural households in Zambia and likely changes in land use and crop management. The linear programming models represent different households in three agro-ecological zones with different cropping patterns and climate trends. The results illustrate that although farms are expected to meet their consumption requirement under climate change scenarios, the probability of falling below a minimum threshold of calorie production increases in two out of three study sites, and this is particularly the case for smallholder famers who facie binding land constraints. The study suggests that autonomous on-farm adaptation generally will not be enough to offset the negative effects of climate change on crop yields but additional adaptation option are needed.

Until to date only few studies have applied mathematical programming to model farming in Vietnam. Firstly, there is the study of Minh et al. (2007) on the optimization of the productivity and sustainability of integrated crop-livestock farming systems in the Midlands of Northern Vietnam. Using linear programming, the study shows that farmers can increase the sugarcane yield, improve soil fertility by using heat-compost from animal and green manures. The results also suggest that farmers in the small, medium and large farm categories should raise livestock up to 4 pigs and 3 buffaloes, 7 pigs and 5 buffaloes, and 20 pigs and 13 buffaloes, respectively. The optimized livestock holdings would directly benefit the sustainable agriculture and thereby improve incomes for farmers.

The second study about farming in Vietnam is the study of Voelker et al. (2013) which assesses the impact of food price shocks on the vulnerability and poverty in the upland areas in Thua Thien Hue province. The Target MOTAD model results show that typical farms are vulnerable to poverty with the probability of 29% in a normal year. Additionally, the food price hike in 2008 made poor farms be poorer and become the losers of higher food prices. The study also finds that farmers' response to price shocks is primarily constrained by the availability of land and access to inputs. These farmers lack good alternatives to illegal forest extraction to generate income such as off-farm and/or non-farm self-employment.

One major question in relation to the application of mathematical programming is the construction of the model and the data that can be used. This is not trivial since farming is generally diverse especially small-scale farmers in developing countries. Crop and livestock portfolios are location-specific and can vary significantly from household to household. Clearly one cannot establish a model for each individual farm. Therefore, the concept of establishing a typical farm for each region becomes essential. Until to date however there is no consensus about the way how to identify a typical farm. Elliott (1928) defined the typical farm as “a modal farm in a frequency distribution of farms of the same universe”. Hatch et al. (1982) stated that the specification of a typical farm “is often associated with the concept of mean or a mode”. Selecting a farm for the construction of a model helps to represent well for a defined group of farms (Thompson, 1958; Feuz and Skold, 1990). Groups of farms can be further disaggregated into smaller groups, which ideally would become more homogeneous.

Following the establishment of typical farm models in agriculture there are at least three ways how one can arrive at typical farm households (Hatch et al., 1982). The first approach is called the economic engineering approach (Feuz and Skold, 1990). Here data are taken from secondary sources and combined and verified with expert knowledge applying a consensus discussion approach. In most cases this would include farmers among the experts. This approach is applied for example by the agri-benchmark projects of the Thünen Institute as a component of international farm comparisons (Zimmer and Deblitz, 2005).

The second approach relies on survey data, which are filtered by a set of well-defined selection criteria in order to arrive at groups of farms or households that are somewhat more homogenous than the entire sample. Thereafter, any farm can be chosen from the reduced sample and used as a base model, which subsequently will be subjected to verification by experts who will include representatives from the respective area (see for example Mausch et al., 2009). Again, after expert verification, the result will be a consensus of what makes a representative farm household. A modified and more scientific variant of this approach is to apply cluster analysis for the establishment of homogenous groups of households and then identify typical households within the clusters followed again by expert verification.

The third approach is a statistical approach. Here the defined sample of farms is used and values for the relevant parameters are derived such as mean, mode or median. The mean can be violated by the outliers especially in case of non-normal distribution. The mode, however, is only of use again of the distribution is symmetric. From a statistical point of view, the median seems to be the most suitable among the three values. When applied to establishment of typical households or farms the statistical approach is consistent and transparent. However, the combination of the median of the variables assumed to be relevant for the formulation of a “typical household” such as land size, labor, age structure, and gender and crop portfolio does not automatically lead to a typical household. Since the correlation among variables is ignored, an aggregation error can occur. Another problem is that in case of a zero inflated data set, the median may in fact turn out to be zero. Another common issue associated with the aggregate farm is the overstatement of the production. Aggregation leads to a combination of resources, which is not possible for individual farms (Hazell and Norton, 1986; Feuz and Skold, 1990). To reduce an aggregation bias, farms must be classified into homogenous groups. However, there are no unique criteria for typical farm selection and classification. These criteria vary depending on the purpose of the research. In most studies, classification is mostly based on three rules: (1) similar proportions in resource endowments, often implying similar land-to-labor ratios; (2) similar yields which usually means the analogous condition of soil, climate, irrigation and topography; (3) similar technologies meaning the same predominant crops/livestock and the similar technologies used in production.

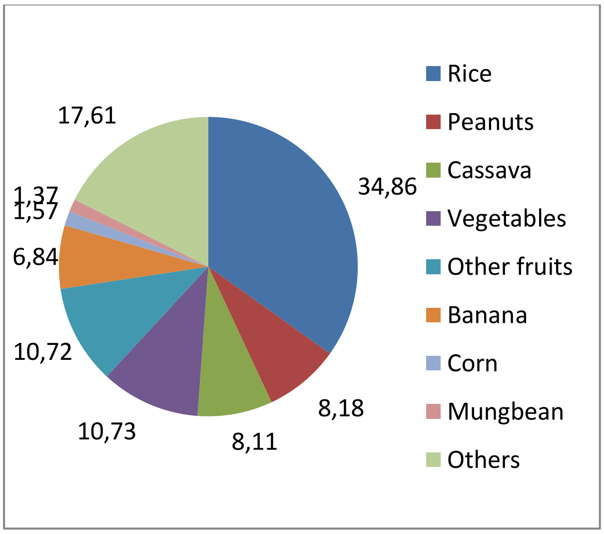
This study generally applies the criteria listed above. The study builds on the paper of Voelker et al. (2013) who included TVSEP 2007 and 2008 data. In this study however five panel waves covering the period of 2007–2013 are included. Therefore, risk can be incorporated in the model. In addition, in this study two typical farm households are developed, i.e. a typical lowland farm and a typical upland farm. The comparison of the two locations will provide a good understanding of the possibilities and limitations how famers in Thua Thien Hue province can cope with climate risks and climate change.

3.3. Definition of Typical Farm Households in Thua Thien Hue

The data used in this study include a five year balanced socio economic panel of Thua Thien Hue province covering the crop years 2006/2007, 2007/2008, 2009/2010, 2010/2011, and 2012/2013 farming seasons. Initially 760 households representing the rural areas of Thua Thien Hue were sampled. The sampling strategy was based on the population density in non-urban communes of the province (Hardeweg et al., 2013). However, stratification has been imposed to avoid under sampling in the less densely populated upland and mountainous areas and three strata for coastal, lowland and upland areas were defined. Since this study focuses on agricultural production the coastal strata, where aquaculture and fishing dominate production activities, is excluded. Consequently, the database includes 219 lowland households and 212 upland households.

The data available for this study include household characteristics and all household income sources including agriculture, off farm wage employment, non-farm self-employment, remittances, public transfers and income from natural resources. Specifically, data outputs and inputs by crop and livestock activities as well as farm-gate product and factor process were collected. In animal production, changes in stock during the reporting period were collected. Data on climate-related risks and shocks and other socio-economic characteristics of the household were recorded according to the respondent's subjective assessments.

Based on the concept of typical farms (see section 2), as much as possible, homogenous groups of households are established. Households from the five year balanced panel data are classified using four criteria. First, households should reside in the same topographic and climatic conditions. Accordingly, sampled households excluded the coastal area are separated into two typical farms, namely the lowland for the plain area and the upland for the mountainous area. Second, typical farms need to be agricultural households in every survey wave where at least one nucleus household member in the working age is engaged in household's own agricultural production. Third, selected farms produce at least one of regionally major annual crops in every survey wave. According to Figure 3.1a, in the lowland the predominant annual crops are rice planted by almost 35% of the households followed by peanuts, cassava and corn. In upland areas the portfolio of annual crops is more balanced with almost 20% rice, over 15% cassava and corn almost 10% (Figure 3.1b).



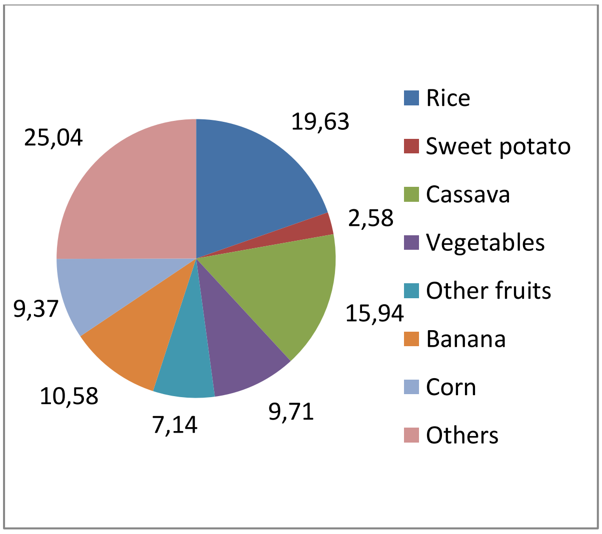
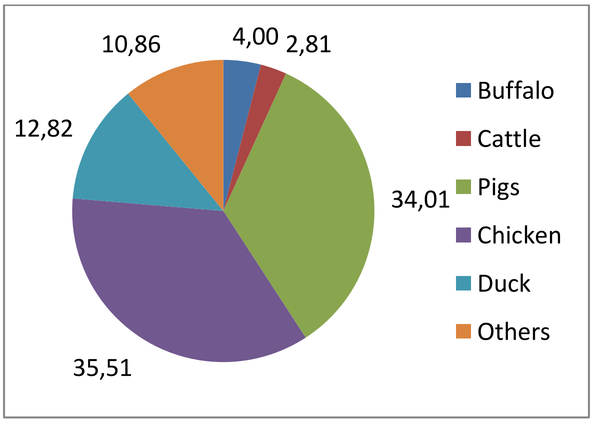


Figure 3.1a: Lowland areas **Figure 3.1b: Upland areas**

Figure 3.1: Major crops in the study areas, in percentage

Source: Own calculations based on TVSEP Household surveys 2007-2013

Fourth, typical farms, in every panel wave, raise at least one of the major small livestock of the region. Figure 3.2 shows that the major small livestock species both in the lowland and the upland areas comprise of chicken and pigs though with different percentage of household reported to keep these species. Specifically, 35.51% for the chicken in the lowland areas and 29.55% in the upland areas whereas 34.01% for the pigs in the lowland and 17.94% in the upland areas.



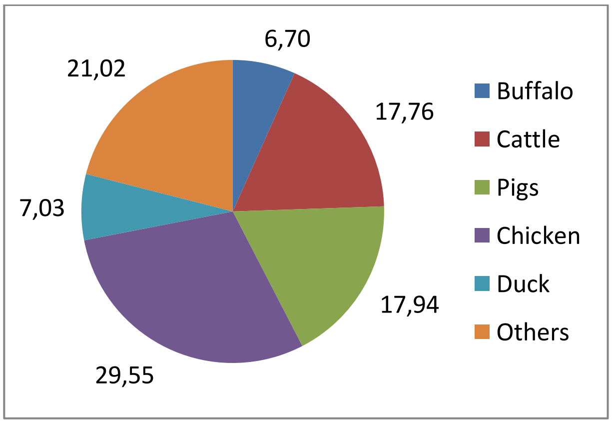


Figure 3.2a: Lowland areas **Figure 3.2b: Upland areas**
Figure 3.2: Major livestock species in the study areas, in percentage

Source: Own calculations based on TVSEP Household surveys 2007-2013

The fourth criterion is livestock integration. Since the number of livestock is higher in upland as compared to lowland areas (see Figure 3.3) different thresholds for the inclusion of a household in the sample are defined. Livestock Units[2] is used as the measure of livestock intensity and the threshold of 0.25 LU are used for lowland and 0.58 for the upland farms.

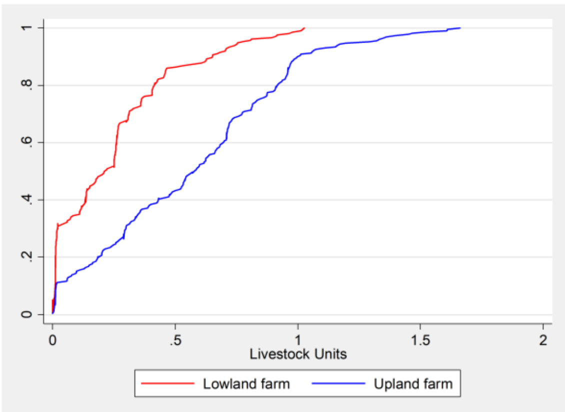


Figure 3.3: Cumulative distribution of Livestock Units in the study areas
Source: Own calculations based on TVSEP Household surveys 2007-2013

[2] Livestock Unit is the aggregated number from different types of livestock based on relative feed requirements at the end of each reference period. The aggregation is done by means of livestock unit coefficients for East and Southeast Asia defined by FAO (2011).

The whole selection procedure for establishing typical households in the two agro-ecological areas of the province[3] is depicted in Figure 3.4. From initially 219 lowland and 212 upland households following four selection criteria, 49 households in the lowland and upland 50 households are finally selected.

Thua Thien Hue province

Selection criteria

Topography and climate conditions	**Lowland areas** (219 households)	**Upland areas** (212 households
At least one nucleus household member in the working age is engaged in household's own agriculture in all five panel waves	106 household	164 households
Plant locally major annual crops in all five panel waves	100 households	101 households
Raise at least one of locally major small livestock species in all five panel waves and has the average Livestock Units equal or greater than the local median value	49 households	50 households

Figure 3.4: Selection scheme of typical farm households in the study areas

Source: Own illustration based on TVSEP Household surveys 2007-2013

[3] Coastal areas are excluded

3.4. Model Construction

In this study the interdisciplinary modelling approach as found in Keil et al. (2009) combining mathematical programming with regression analysis has been applied. In the first stage, the effect of climate-related shocks on crop production is estimated. A Cobb-Douglas production function has been specified with the general form as follows:

$$\ln Y_{ci} = \beta_{ci0} + \sum_{r=1}^{s} \beta_{cim} D_{cim} + \sum_{k=1}^{l} \beta_{cik} \ln X_{cik} + \varepsilon_{ci} \tag{1}$$

where *c* stands for major crop (rice, cassava and corn), ln*Y* is the natural logarithm of the output of farm household *i*. The independent variable vector comprises of natural logarithm ln*X* of inputs *k (k=1,.., l)* such as land, labor, fertilizer, seeds and pesticides. Other components of independent variables include dummies for the climate-related shocks *r (r=1,…, s)* such as drought and storms which are supposed to have negatively affected farm[4]. β_0, β_r, β_k are the vector of parameters to be estimated and ε is the error term. The estimation of Cobb-Douglas production functions will be executed on the whole sample by Ordinary Least Squares (OLS) method in Stata 14.2

In the second stage, the optimal organization with a resource allocation aimed at maximum annual income for two typical farms has been conducted by means of mathematical programming. Due to the inherent risks in agricultural production such as droughts, floods, pests and diseases, the coefficients of the objective function are stochastics. Furthermore, in that risky environment, farmers are often found to behave in risk-averse ways (Binswanger, 1980; Yesuf and Bluffstone, 2009; Liu, 2013). In such case, a stochastic approach which formally incorporates risk must be used. In linear programming the MOTAD (Minimization Of Total Absolute Deviations) model and its extension namely Target MOTAD (Tauer, 1983) which generates risk-efficient solutions that meet the second-degree stochastic dominance test (e.g. Salimonu et al., 2008) are commonly employed.

The Target MOTAD model is formally presented in the set of equations 2. The model specifies the objective function with a maximization of expected gross margin under the condition of a specified minimum income target:

[4] Only shocks which, according to household's subjective assessment, affected household with medium or high level of severity are included

Maximize $$E(z) = \sum_{j=1}^{n} c_j x_j \quad (2a)$$

subject to $$\sum_{j=1}^{n} a_{kj} x_j \le b_k \qquad k = 1,\dots\dots,m \quad (2b)$$

$$T - \sum_{j=1}^{n} c_{rj} x_j - y_r \le 0 \qquad r = 1,\dots\dots, s \quad (2c)$$

$$\sum_{r=1}^{s} p_r y_r = \lambda \qquad \lambda = M -> 0 \quad (2d)$$

for all $x_j \ge 0, y_r \ge 0$

where:

$E(z)$: expected total gross margin of the solution set

c_j : expected gross margin per unit of activity j

x_j : level of activity j

a_{kj} : technical requirement per unit of activity j for resource k

b_k : level of resource k

T : target level of gross margin

c_r : gross margin per unit of activity j in the state of nature r

y_r : deviation below T for the state of nature r

p_r : probability that state of nature r will occur

λ : a constant parameterized from M to 0

M : a large number

While equation (2a) maximizes the sum of expected gross margin of the farming plan where gross margin is defined as gross income less variable costs (FAO, 2018), equation (2b) specifies the technical constraints of the farm. Equation (2c) measures the gross margin in each state of nature. In this analysis, the gross margin of crops in different states are built up based on the mean and the coefficients of climatic dummies in the regression of Cobb-Douglas production functions (see equation 1) while the gross margin of livestock is taken either from the best year or from the worst year. Stochastic incomes are allowed to deviate negatively from the defined safety level of income *T*. Negative deviations weighted by the probabilities of occurrence are summed up in equation (2d) and are regarded as the measurement of risk (Tauer, 1983). Risk-averse farmers whose major concern is survival might choose the plan that has the smallest negative deviations whereas moderately risk-averse farmers might prefer plans with higher level of income provided deviations are reasonably small (Hazell and Norton, 1986). Target MOTAD model will be solved in GAMS 25.0.2[5]

The models of the two typical farms represent one agricultural year and there is a static model. The objective function includes all farm and non-farm production, purchase and sales activities. Cropping activities are seasonal depending on climatic conditions of the typical farms. For example, two rice crops per year, namely the winter-spring rice cropped from January to April and the summer-autumn rice from May to August. The season of cassava is from January to December, peanuts from January to April and corn from January to April. Livestock includes chicken and pig production at different levels of intensity and with different livestock products. Chicken production includes free-range, backyard type activities which use crop by-products as feed (FAO 2000; Hong Hanh et al., 2007; FAO, 2008)[6]. Chicken production is formulated in the model as two production cycles per year. In swine production three activities were formulated: i) fattening, ii) breeding sow and ii) weaner production.

The resource constraints of the model include labor, land, working capital (cash) and food consumption requirements. Labor constraints define farm's labor capacity on a monthly basis. Seasonality is taken into account by adjusting labor capacities for weather-dependent farm activities (Hazell and Norton, 1986). Technical labor coefficients are formulated for each of farm activities. Labor constraints are eased by the possibility to hire laborers at a constant wage rate. Land constraints specify farm's land endowment for annual crops and livestock production and their biological limitations for crop type due to requirements for climatic conditions and soil types. For livestock, stall capacity constraints are formulated that limit the expansion of livestock production without investments. Furthermore, cash constraints are formulated on a monthly basis. Cash constraints refer to the farm's available working capital needed to finance purchases of production inputs such as seeds, fertilizers, pesticides or feeds, young livestock, veterinary treatment and hired labor as well as to finance

[5] GAMS standing for General Algebraic Modeling System is a high-level modeling system for mathematical optimization developed by GAMS Development Corporation (https://www.gams.com)

[6] Traditional, extensive backyard poultry production is characterized with the small scale with flock size smaller than 50 birds and it is the most common production system in Vietnam. In this system, poultry is raised in garden, backyards and has free scavenging. Poultry is additionally fed with limited amounts of home produced grains. The amount of feed for poultry does not focus on production efficiency but depends heavily on the availability of home production and consumption (Burgos et al., 2007).

household consumption. Monthly cash surplus can be transferred on a monthly basis. For the consumption equations minimum requirements for the major food items (e.g. rice, peanut, cassava and chicken) are formulated.

Risks in the farm activities are depicted in corresponding risk constraints. Different states of nature (for example pest, drought and livestock diseases) have different occurrence possibilities. These are based on self-reported shock events. Shock outcomes (e.g. yield losses) were then derived from the Cobb-Douglas production function. Deviations in the revenue from the target income are considered in the risk rows of the model. The target income is defined as the minimum expenditure level self-reported by the farm households. The sum of negative deviations in each state of nature multiplied by its probability constitutes another risk constraint. Follow Tauer (1983) and Zimet and Spreen (1986), this risk parameter is parameterized starting from zero upwards.

3.4.1. Technical Parameters

Table 3.1 represents typical farms' major annual crop portfolio and crop technical parameters used in the Target MOTAD models. The parameters are constructed based on the mean values of production inputs and output of the 49 selected households in the lowland areas and the 50 selected households in the upland areas of Thua Thien Hue province during the five-year survey waves from 2007 to 2013. Following the procedure of Keil et al. (2009) outliers at 5% threshold of the density function are excluded in order to minimize the outlier bias.

Crop areas for rice, cassava, peanut and corn show that total farm size is below one ha considering that rice has two crops per year. Farm size is smaller in the uplands which underlines the higher poverty rate. Crop yields are measured in dried paddy rice, fresh cassava, fresh maize, and hulled peanut. Table 3.1 shows that rice, which includes winter-spring rice and summer-autumn rice is the most important crop in terms of cropped area and gross margin. Crop yields and corresponding gross margins are higher for the lowland farm. Labor input is measured in man days per ha while machine use input for land preparation and harvesting is dichotomous. The major material inputs, namely seeds, fertilizer, pesticide and irrigation are presented in 2005 PPP$. Input intensity (except for labor) in the lowland farm is higher than in the upland farm corresponding with the difference is productivity.

Table 3.1: Technical parameters for major crops of the typical farms

Technical parameters	Lowland					Upland			
	Winter - spring rice	Summer -autumn rice	Peanut	Cassava	Maize	Winter - spring rice	Summer -autumn rice	Cassava	Maize
Output									
Yield (kg/ha)	4734.9	4453.9	1894.2	13808.3	4555.2	3015.5	2760.2	11312.2	3159.6
Gross margin(PPP$/ha)	1635.2	1547.8	1563.3	1258.3	1081.9	1201.3	1202.0	1040.6	1157.4
Input									
Land[7] (ha)	0.354	0.354	0.057	0.057	0.004	0.161	0.161	0.101	0.033
Labor (MD/ha)	82.6	84.4	131.1	121.9	128.1	154.2	177.9	181.1	144.2
Machine for land preparation (Y/N)	Yes	Yes	Yes	Yes	Yes	No	No	No	No
Machine for harvesting (Y/N)	Yes	Yes	No	No	No	No	No	No	No
Seedlings (PPP$/ha)	139.9	124.7	375.1	67.8	169.8	139.2	132.1	38.6	96.2
Fertilizer (PPP$/ha)	959.9	880.5	499.1	410.8	658.9	419.0	385.3	46.8	265.0
Pesticides (PPP$/ha)	205.9	194.2	65.5	8.4	163.4	73.2	68.5	9.2	10.8
Irrigation (PPP$/ha)	155.2	154.9	0	0	5.9	0.5	0.5	0	0

Source: Own calculations based on selected households from TVSEP Household surveys in 2007-2013

[7] Land inputs are exclusively reported in three digits after the decimal point due to the small farm size in the study areas.

The technical coefficients and objective values for livestock production are shown in Table 3.2. Following the procedure of identifying typical farm households, most of the coefficients are mean values from the selected homogenous farm groups from five year panel survey (2007-2013). Labor coefficients are extracted from the recent panel wave (i.e. 2017) data because detailed labor data in livestock production were not collected in previous waves. Coefficients, which were not collected in TVSEP household survey such as restocking rates, number of piglets per sow, weaning periods for piglets or fattening periods, are based on the literature of England et al., 1980; La et al., 2002; Huynh et al., 2006; and Lemke et al., 2008.

Table 3.2 shows the stock density of chickens and the three pig production activities, namely pig fattening, breeding sow and production of weaners. Similar to crop production the scale of small livestock production is higher in the lowland farm than in the upland. However, the values of gross margin per livestock head are almost the same between these two farms. Even the gross margin per fattener is larger in the upland farm than in the lowland farm. It is partly because the direct input coefficients including restocking, feeds (both home produced and purchased) and veterinary costs are reported lower by the upland farm than the lowland farm. Labor used for one head of pig either fattener or sow in the lowland farm is substantial higher that in the upland counterpart.

Table 3.2: Technical parameters for major small livestock of the typical farms

Technical parameters	Lowland				Upland			
	Chicken	Fattener	Sow	Weaner	Chicken	Fattener	Sow	Weaner
Output								
Stock (head/year)	36	4	2	28	22	2	1	14
Gross margin (PPP$/head)	9.9	32.2	-	54.1	10.3	49.1	-	51.5
Input								
Labor (MD/head)	0.5	6.8	13.9	2.3	0.5	4.4	8.0	1.3
Restocking (PPP$/head)	2.1	96.5	-	6.8	1.8	77.6	-	6.0
Bought feed (PPP$/head)	0.6	45.3	124.3	-	0.3	30.7	95.5	
Home-produced rice (kg/head)	1.1	30.0	60.0	-	0.5	9.2	18.4	-
Home-produced cassava (kg/head)	0.35	9.5	19.0	-	0.3	8.8	17.6	-
Home-produced corn (kg/head)	-	0.1	0.3	-	-	0.9	1.9	-
Veterinary treatment (PPP$/head)	0.1	5.0	2.2	0.1	0.1	1.9	1.9	0.1

Note: Weaner stock is based on Lemke et al., 2008: Labor data is extracted from survey 2017 since no labor data in 2007-2013
Source: Own calculations based on selected households from TVSEP Household surveys in 2007-2013

3.4.2. Model Assumptions Regarding the Climate Effects on Agricultural Production

In order to investigate the impact of climatic shocks on agricultural production of the typical farms shock modules are the survey instruments of the different years whereby households were asked for the shock experience in the reference period[8]. Figure 3.5 shows the share of farm households reporting climatic shock experience. It is obviously shown that upland farm households were exposed to more shocks than lowland farms. Throughout the survey waves crop pest outbreaks and livestock diseases were the most frequently experienced shock, followed by flooding and storm. In 2010 a large share of farm households reported storm and floods occurred in the previous year. This self-report is in line with the serious floods in the Central Coast of Vietnam in 1999 (ADRC, 1999; IFRC, 1999; Department of Science and Technology of Thua Thien Hue, 2004)

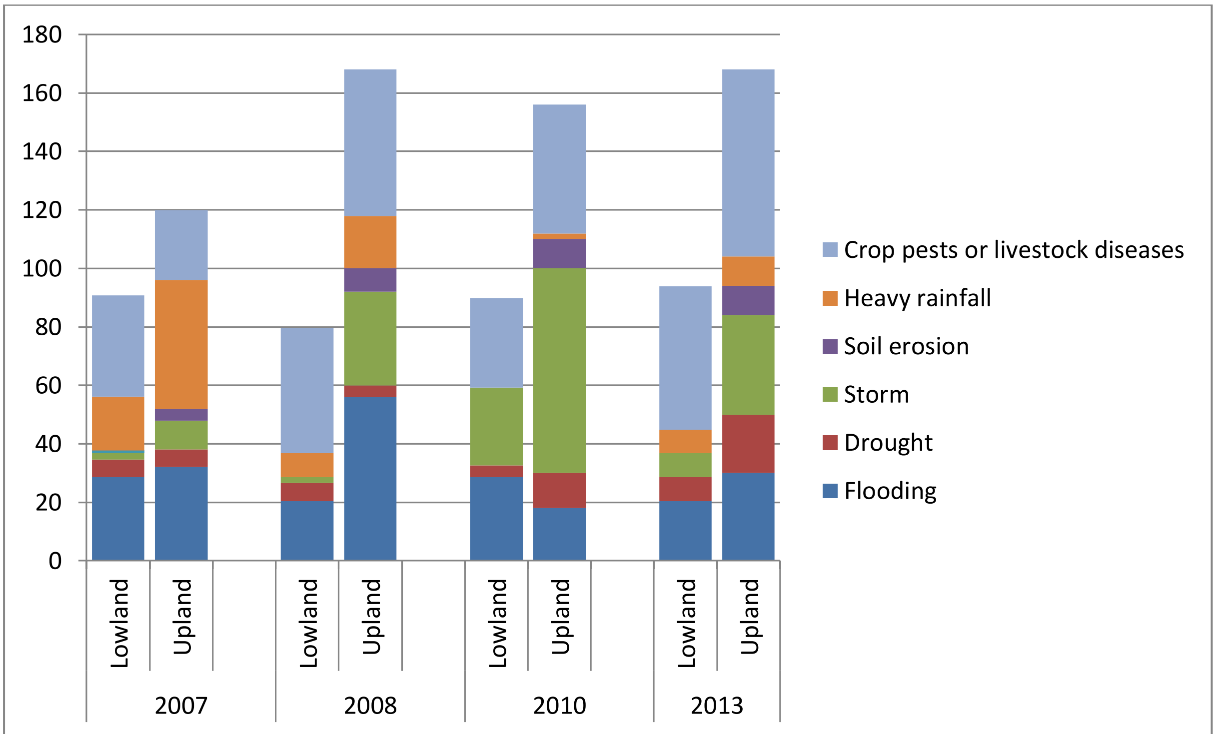


Figure 3.5: Percentages of households reporting climatic shocks
Source: Own calculations based on selected households from TVSEP Household surveys 2007-2013

[8] The reference periods were the preceding five years for the first wave, the duration from 05/2007 to 04/2008 for the second wave, the duration from 05/2008 to 04/2010 for the third wave, the duration from 05/2010 to 04/2011 for the fourth wave and the duration from 05/2010 to 04/2013 for the fifth wave. Given the overlap in the reference period between the fourth and the fifth wave, the fourth wave is excluded in this shock experience part.

Severity of the shocks as perceived by households was also elaborated by the respondents (mostly household heads) on a four point ordinal scale, whereby 0 = no impact, 1 = low, 2 = medium and 3 = high impact. Table 3.3 shows average self-estimated severity scores for each type of climatic shocks and in each wave for the two agro ecological zones. Scores are high especially for the three most commonly reported shocks (i.e. flooding, storm and crop pests or livestock diseases) for both zones while upland farms were subjectively affected more severely. Results underline that the perceptions of households correspond well with external weather data.

Table 3.3: Self-estimated severity of impacts of climate-related shocks

Years	Zone	Flooding	Storm	Pests/ Diseases	Drought	Heavy rainfall	Soil erosion
2007	Lowland	2.79	3.00	2.82	3.00	2.22	-
	Upland	2.56	2.80	2.25	2.00	2.86	2.50
2008	Lowland	1.90	3.00	2.05	1.33	1.00	-
	Upland	2.23	2.69	2.48	2.50	1.33	2.25
2010	Lowland	2.57	2.38	2.47	2.00	-	-
	Upland	2.89	2.69	2.70	2.50	2.00	2.60
2013	Lowland	2.25	2.00	2.46	2.50	-	-
	Upland	2.64	2.54	2.72	2.70	-	2.33
Average	**Lowland**	**2.38**	**2.60**	**2.45**	**2.20**	**1.61**	**-**
	Upland	**2.58**	**2.68**	**2.54**	**2.43**	**2.00**	**2.42**

Source: Own calculations based on selected households from TVSEP Household surveys 2007-2013

The effects of climate-related shocks on crop yields are quantified by means of the Cobb-Douglas production functions for all major crops. For the aim of a larger number of observations, the pooled data from whole sample for lowland and upland areas are included in the regression analysis. The inclusion of climatic shock types in the regression is determined by the self-reported time of shock occurrence and the cropping season. For example, cold shock and drought shock are included in the regression for winter-spring rice but storm, rain, flooding and droughts are only entered in the regression for summer-autumn rice. Pest shocks are included in all equations as these can occur throughout the crop year.

The estimation of Cobb-Douglas production function is executed in Stata 14.2 by means of the ordinary least squares method (OLS). Regressions are run separately for different crops for both regions together. Results are shown in Table 3.4. As expected, climate-related shocks generally have negative effects on crop yields. Rice is affected in both seasons and by more types of events including pests, drought and flooding. The severity of negative effect is, however, not as high as that found in other crops. In contrast, corn and peanut are sensitive to fewer types of risks but with higher level of severity. Regression results for cassava also show the negative impact of climate-related risks such as pests, flooding though these risk coefficients are not statistically significant. The dummy variable for upland farms is meant to measure the general difference in productivity between the two areas. The coefficients of interaction terms of climate-related shocks with upland dummy are not statistically significant in all regressions. That means the effect of climate-related events on crop yields was not significantly different between lowland and upland regions.

Table 3.4: OLS estimates of Cobb-Douglas production function for major crops

Variables	**Winter-spring rice**	**Summer-autumn rice**	**Peanut**	**Cassava**	**Maize**
Land (ha)	0.430***	0.613***	0.531***	0.572***	0.525***
	(12.11)	(11.61)	(8.89)	(7.67)	(8.18)
Labor (MD)	-0.004	-0.048	0.208*	0.142	-0.125
	(-0.12)	(-1.16)	(1.67)	(1.22)	(-1.25)
Seed (PPP$)	0.183***	0.126***	0.167***	0.189***	0.254***
	(5.39)	(3.34)	(3.48)	(3.84)	(4.04)
Fertilizers (PPP$)	0.188***	0.176***	0.108*	0.192	0.095
	(6.87)	(5.49)	(1.85)	(1.05)	(1.24)
Pesticides (PPP$)	0.102***	0.065**	0.075	-0.311	0.006
	(4.67)	(2.51)	(1.55)	(-0.83)	(0.04)
Number of plots	-0.005	0.004	-0.010	0.022	0.012
	(-0.45)	(0.43)	(-0.37)	(0.70)	(0.30)
Rainfed share	-0.124**	-0.268***			
	(-2.23)	(-3.36)			
Pest shock (Y/N)	-0.144*	-0.152***	0.157	-0.242	-0.146
	(-1.56)	(-3.10)	(0.75)	(-0.56)	(-0.20)
Pest shock* Upland (Y/N)	-0.032	0.094	0.000	0.182	-0.081
	(-0.21)	(0.67)	(.)	(0.38)	(-0.10)
Rain shock (Y/N)		-0.049		0.335	-0.222
		(-0.66)		(0.89)	(-0.39)
Rain shock* Upland (Y/N)		-0.045		-0.401	0.052
		(-0.35)		(-0.98)	(0.09)
Cold shock (Y/N)	-0.120		-0.856***	0.046	-0.706*
	(-1.20)		(-3.53)	(0.10)	(-1.82)
Cold shock* Upland (Y/N)	0.032		1.147	-0.440	0.000
	(0.12)		(3.86)	(-0.92)	(.)
Drought shock (Y/N)	-0.122*	-0.158*	-0.430*	0.453	-0.254*

	(-1.94)	(-1.40)	(-1.70)	(0.94)	(-1.71)
Drought shock* Upland (Y/N)	-0.095	-0.136	0.000	-0.469	0.000
	(-0.86)	(-0.85)	(.)	(-0.93)	(.)
Flooding shock (Y/N)		-0.136^{***}		-0.063	
		(-3.89)		(-0.25)	
Flooding shock* Upland (Y/N)		0.084		-0.059	
		(0.80)		(-0.21)	
Storm shock (Y/N)		-0.099			
		(-1.38)			
Storm shock* Upland (Y/N)		0.126			
		(1.48)			
Upland (Y/N)	-0.300^{***}	-0.332^{***}	-0.395^{**}	0.151	-0.449^{*}
	(-6.13)	(-5.22)	(-2.59)	(0.94)	(-1.85)
Intercept	5.646^{***}	6.634^{***}	4.181^{***}	6.684^{***}	7.406^{***}
	(22.35)	(17.69)	(6.23)	(8.38)	(11.45)
N	1024	857	119	314	280
R^2	0.728	0.761	0.804	0.424	0.479

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, t statistics in parentheses
Source: Own calculations based on TVSEP Household surveys 2007-2013

In livestock production, diseases negatively affect productivity through deaths, morbidity and reduce profits due to the costs of preventive and curative measures (FAO, 2018). Additionally, the disease outbreaks usually lead to the shift of consumption to other animal proteins as consumer concern about meat safety. This causes meat price of the affected livestock to decline substantially (FAO, 2006). So putting it all together, the livestock disease emergence makes gross margin of livestock activity decrease.

In this analysis it is assumed that livestock production is only negatively affected by livestock disease shock, not by the other climate-related shocks. It is additionally assumed that there are only two states of nature, namely with the occurrence of livestock diseases and without the occurrence of livestock diseases. The gross margin of livestock in the former state is assumed to be the gross margin in the worst year and in the latter state to be the gross margin in the best year among five waves. Specifically, the worst year for the lowland both in terms of chicken and pig production was 2007 and for the upland counterpart was 2008 (see Table 3.5). This self-report is consistent with the outbreak of porcine reproductive and respiratory syndrome (PRRS) which dramatically devastated pig production in Vietnam in two years 2007 and 2008 (APHIS, 2007; FAO, 2007; Zhang et al., 2015). The best year for chicken was 2008 for the lowland and 2010 for the upland while for pigs was 2010 and 2011, respectively. Variances in Table 3.5 point out that the lowland farm suffered from higher income variability than the upland farm when raising chicken and pigs.

Table 3.5: Gross margin of major small livestock over years of typical farms (PPP$)

Year	Lowland farm		Upland farm	
	Chicken	Fattener	Chicken	Fattener
2007	6.3	-34.6	10.6	29.5
2008	13.7	24.9	7.7	24.8
2010	11.7	69.2	12.8	56.9
2011	9.2	46.2	9.8	77.9
2013	9.1	55.6	11.5	56.4
Average	**10.0**	**32.3**	**10.5**	**49.1**
Variance	**7.9**	**1656.9**	**3.6**	**480.7**

Source: Own calculations based on selected households from TVSEP Household surveys 2007-2013

3.5. Target MOTAD Model Solutions

Based on the marginal effects of the climate-related risk coefficients in Table 3.4 and the mean of crop yield, crop gross margins are then calculated for different states of nature, namely no climatic shock, pest shock, drought shock, cold shock and flooding shock. With reference to livestock, there are only two states, namely with or without livestock disease shock. The gross margin of livestock in the former state is assumed to be the lowest gross margin and in the latter state to be the highest gross margin among five waves (see Table 3.5). Six risk rows for six states of nature together with one row for the expected sum of negative deviations of gross income from the target income build up the set of risk constraints in the Target MOTAD model. These risk constraints combining with resource constraints, consumption constraints and objective function construct a complete matrix of the model. The matrix is then solved in the computer program GAMS 25.0.2 to figure out the optimal resource allocation among production activities. Two models are run separately for the lowland and the upland farms. The farmer's observed plan and the model solution for the lowland farm are presented in Table 3.6.

According to Table 3.6 the Target MOTAD solution (Plan II) has lower return than the observed farmer's pattern (Plan I). The results also point out that land areas allocated to crop activities are somewhat different between these two plans. Specifically, in Target MOTAD plan, summer-autumn rice should be cropped with the maximum area of 0.3 ha which is slightly higher than the area actually cropped by the farmer. Another difference found in the

Table 3.6: Farming patterns of the observed plan and Target MOTAD model solution of the lowland farm

	Unit	(I) Farmer's plan	(II) Target MOTAD plan
Total gross income	**PPP$**	**6473.8**	**4785.2**
Land			
Land for winter-spring rice	ha	0.300	0.300
Land for summer-autumn rice	ha	0.260	0.300
Land for intercropped cassava and peanut	ha	0.127	0.000
Land for corn	ha	0.004	0.131
Livestock			
Chicken	Head	36	0
Sow	Head	1	0
Fattener	Head	2	0
Weaner	Head	14	0
Labor			
Monthly endowment for all farming activities	MD	36.2	36.2
Labor for major farming activities in January	MD	24.8	22.0
Labor for major farming activities in February	MD	11.8	9.2
Labor for major farming activities in March	MD	4.9	1.8
Labor for major farming activities in April	MD	10.4	8.4
Labor for major farming activities in May	MD	24.6	13.3
Labor for major farming activities in June	MD	17.1	4.8
Labor for major farming activities in July	MD	6.5	1.9
Labor for major farming activities in August	MD	9.2	5.1
Labor for major farming activities in September	MD	2.3	0
Labor for major farming activities in October	MD	2.3	0
Labor for major farming activities in November	MD	12.9	0
Labor for major farming activities in December	MD	14.5	0
Hired labor	MD	0	0

Source: Own calculations based on selected households in TVSEP Household surveys 2007-2013

land allocation is that the whole area for other crops than rice should merely go to corn. Regarding livestock, Target MOTAD plan includes neither chicken nor pig. This highly contrasts with the observed plan.

As the matter of fact, raising pig is quite risky in many regions in Vietnam and mostly due to the volatile pork prices, disease outbreaks and mortality (Nguyen and Nanseki, 2015; Zhang et al., 2015). According to the study of Zhang et al. (2015) on the outbreak of Porcine

Reproductive and Respiratory Syndrome (PRRS) in Huong Tra district in the lowland area of Thua Thien Hue province, one main reason for the high risk of disease outbreaks and then mortality is the low level of vaccination for pigs among pig farmers. Similar to pig, chicken is not efficiently vaccinated in traditional, extensive backyard poultry production because of the free range raising system. Furthermore, small-scaled farmers do not pay much attention to the prevention and treatment of chicken diseases. As a consequence, epidemic diseases can rapidly spread out once they outbreak. The mortality rate of chicken in the small-scaled farm is hence pretty high, namely 40% - 60% on average nationwide (FAO, 2008). These lead to a highly volatile income generated by chicken and pigs. The high volatility is demonstrated by the large standard deviation in livestock gross margin over five waves. The model results additionally show quite high “reduced cost” associated with raising chicken and pigs. Since Target MOTAD is a risk minimized model, the high risks associated with production of chicken and pigs may explain for their absence in the model. Consequently, the total gross margin of lowland farm in the model solution is much lower than that in the observed plan.

Despite the riskiness of livestock production mentioned above, chicken and pigs appear in the observed plan of farmers (Plan I). It might be interpreted by the fact that nationwide in Vietnam around 50% of households keep poultry (Moula et al., 2011) and approximately 60% rural household raise pigs accounting for 75.45% of total livestock production (Nguyen and Nanseki, 2015; Zhang et al., 2015). Backyard chickens are kept for their social-cultural and economic roles. Chicken are indispensable in many social and religious events such as Tet New Year festival or for entertaining guests, feeding sick people or giving relatives/friends as a gift. Chicken also serve as the main source of animal protein for rural households. Furthermore, chicken usually provide income for farm’s small expenditure as school fees and clothes for children (Burgos et al., 2007; Lemke et al., 2008; Moula at al., 2011). Different from chicken, pigs are kept mainly not for home consumption but for sale either on schedule or not. So pig serves as an important source of household’s income or a form of savings (Huynh et al., 2006; Lemke et al., 2008). Another common reason why chicken and pigs are kept in small-scaled farms is that farm can take use of the kitchen waste to feed these livestock species.

With reference to labor constraint, Table 3.6 shows a large number of labor abundancy due to the seasonal nature of agricultural work. Accordingly, the amount of redundant labor varies from month to month. Only in January and May where winter-spring rice and summer-autumn rice are planted respectively, labor is most required. The rest of time in the year, much less of farm work has to be done and thus less labor is required. These results are in line with the real situation of labor in agriculture sector of Vietnam. While the official rural unemployment rate is quite low, at 1.82% on national average (GSO, 2016), the time-related underemployment in rural areas remains a current concern of Vietnam with the remarkable rate of more than 70% (Shintani, 2001; Beresford and Tran, 2004; De Brauw, 2007).

The seasonal underemployment is even absolutely higher in the upland farm (Table 3.7). Results in this table also imply that the observed total income of upland farm (Plan III) is substantially lower than that of lowland farm (Plan I). Land allocation among annual crops is also different between these two farms. Specifically, upland farm has smaller area of rice but larger area of corn compared to the lowland farm. In regard to livestock, upland farm keeps less chicken and pigs than lowland farm. Comparing the observed plan (III) and Target MOTAD model solution for the upland farm (IV) shows that farm should re-allocate slightly land endowment among annual crops in order to be optimal. Specifically, the upland farm should make use of the rest of rice land for cropping in summer–autumn season and increase the area for cropping corn by decreasing the area for cassava. The livestock portfolio should be as the same as what are observed. These are exactly the maximum amount that farm can keep under the stall area constraints.

In summary, the observed farmer’s plan of the typical lowland farm looks much different from that plan generated by the Target MOTAD model in which livestock production should not be included. The reason for this exclusion lies in the high variance in livestock gross margin values and “reduced cost” of livestock production in the region in the study period. Rice and corn should be the only two annual crops in the optimal portfolio of lowland farm. These two crops are also found in the optimal plan for the upland farm. Different from the lowland, upland farm should keep livestock in order to have the optimal income. In both lowland and upland farms, agricultural labor is found not to be fully utilized especially in the off-seasons. Also for both farms especially the lowland farm, the total gross margins induced by the model lower than what are observed in the farmers’ plans. The reason for those discrepancies is the exclusion of risky livestock production in the lowland areas and small re-allocation of land among crops. Interpretation for different portfolios between farmers’ observed plan and model solution is that Target MOTAD model does not only aim to maximize the total gross income of farm households but also to minimize agricultural income risks. Hence, risky production activities do not come into the model solution in order to assure farmers a certain safe income level.

Table 3.7: Farming patterns of the observed plan and Target MOTAD model solution of the upland farm

	Unit	(III) Farmer's plan	(IV) Target MOTAD plan
Total gross income	**PPP$**	**4144.9**	**3938.9**
Land			
Land for winter-spring rice	ha	0.108	0.108
Land for summer-autumn rice	ha	0.104	0.108
Land for cassava	ha	0.066	0.005
Land for corn	ha	0.029	0.091
Livestock			
Chicken	Head	22	22
Sow	Head	1	1
Fattener	Head	2	2
Weaner	Head	14	14
Labor			
Monthly endowment for all farming activities	MD	44.9	44.9
Labor for major farming in January	MD	19.5	19.2
Labor for major farming in February	MD	7.0	7.7
Labor for major farming in March	MD	3.1	2.5
Labor for major farming in April	MD	2.3	1.4
Labor for major farming in May	MD	13.5	13.5
Labor for major farming in June	MD	16.9	18.9
Labor for major farming in July	MD	5.6	5.6
Labor for major farming in August	MD	3.8	3.8
Labor for major farming in September	MD	1.4	1.4
Labor for major farming in October	MD	8.2	8.4
Labor for major farming in November	MD	7.7	7.7
Labor for major farming in December	MD	10.9	8.0
Hired labor	MD	0	0

Source: Own calculations based on selected households in TVSEP Household surveys 2007-2013

3.6. Sensitivity Analysis

In the next step, the constraints for land, labor and cash are set to vary from those in the base model to investigate the sensitivity of the models. With reference to the lowland farm, it is assumed that typical farm can rent additionally land to increase the farm size if profitable though rural land rental markets remain inefficient (Deininger et al., 2003; Ravallion and van de Walle, 2008). Concerning labor, it is assumed that 10% of redundant agricultural labor of the farm can be solved through off-farm job opportunities. The underemployed family member can either migrate seasonal or travel daily from home to workplace so that he/she can manage both off-farm occupation in off-season and on-farm work in peak season. Regarding to cash availability, the constraint is relaxed by allowing farm to borrow maximum 984.58 PPP$ with an interest rate of 6.41% per year from banks or any moneylenders. All of these assumptions are made based on the descriptive statistics in land, off-farm employment and savings and borrowing sections in the household survey.

The optimal solutions for different scenarios are illustrated in Table 3.8. Specifically, under the scenario of renting more land, farm should rent an area of 0.75 ha for rice cropping in two seasons. Similar to the Target MOTAD base model (Plan II), the Target MOTAD in this scenario does not include any livestock (Plan V). Without income from livestock, farm therefore has to borrow the maximum amount of 984.58 PPP$ to finance the rental. This borrowing is also found in the plan of next scenario where not only land constraints are relaxed but 10% of agricultural labor abundancy is reduced (Plan VI). However, with off-farm income from that 10% agricultural labor, farm may even rent larger area of 0.922 ha for rice. Due to the exclusion of chicken and pigs out of production patterns in both scenarios, the total gross incomes of the lowland farm generated by Target MOTAD model remain lower than the farm’s actual income. The results imply that relaxation in land and capital constraints help to boost farm income in the lowland areas. Nevertheless, this income improvement is still not able to offset the foregone earnings from livestock production.

Table 3.8: Farming patterns in different scenarios of the lowland farm

	Unit	(V) Plan with additionally rented land	(VI) Plan with additionally rented land and more off-farm labor
Total gross income	**PPP$**	**5450.05**	**6156.62**
Land			
Land for winter-spring rice	ha	1.050	1.222
Land for summer-autumn rice	ha	1.050	1.222
Land for intercropped cassava and peanuts	ha	0	0
Land for corn	ha	0	0
Additionally rented land	ha	0.750	0.922
Livestock			
Chicken	Head	0	0
Sow	Head	0	0
Fatteners	Head	0	0
Weaner	Head	0	0
Labor			
Monthly endowment for all farming activities	MD	36.2	36.2
Labor for major farming activities in January	MD	36.2	36.2
Labor for major farming activities in February	MD	17.6	36.2
Labor for major farming activities in March	MD	6.6	35.4
Labor for major farming activities in April	MD	18.1	21.1
Labor for major farming activities in May	MD	36.2	36.2
Labor for major farming activities in June	MD	16.9	19.7
Labor for major farming activities in July	MD	6.7	7.8
Labor for major farming activities in August	MD	18.1	21.1
Labor for major farming activities in September	MD	0	0
Labor for major farming activities in October	MD	0	0
Labor for major farming activities in November	MD	0	0
Labor for major farming activities in December	MD	0	0
Hired labor	MD	18.6	33.6
Borrowing	PPP$	984.5	984.5

Source: Own calculations based on selected households in TVSEP Household surveys 2007-2013

Regarding the upland farm, there are four different scenarios. First, it is assumed that upland farm may enlarge the stall areas with double capacity for both chicken and pigs and the livestock output market may be elastic enough for that enlargement. The model results for this scenario, Plan VII in Table 3.9, imply that farm would keep both types of livestock at its maximal capacity. Regarding cropping, there would be no change in rice area but a small re-allocation of 0.003 ha area from corn to cassava. In the second scenario, it is supposed that farm could transform a portion of its total land in a way that land suitable for rice and land suitable for other annual crops got doubled. In this case, farm would crop rice, similar to other plans, at its maximal area (Plan VIII). The area for corn should be also increased to 0.186 ha. Conversely, cassava area should remain at small level of 0.005 ha. In the third scenario, 10% of the redundant agricultural labor is assumed to find a seasonal job in Hue City or in other provinces. Under this assumption, the major cropping and livestock keeping activities (Plan IX) should stay the same as those in the base model (Plan IV). The fourth scenario combines assumptions of the three former scenarios. The solution results (Plan X) are found in similar manner with other scenarios where rice should be planted at the maximum level and corn should get larger area than cassava. In addition, chicken and pigs are raised at the highest capacity. Part of agricultural labor should look for seasonal off-farm job opportunities to increase farm income. Similar to the case of lowland farm, the total gross income values in all four scenarios for the upland farm are higher than that in the in the base model solution (Plan IV). However, the scenario plans in the upland case can generate higher total gross margin than the actual farm households' income. It is because beside extra income generated by relaxed resource constraints, chicken and pig production, which bring about a considerable amount of income and has zero "reduced cost" and low variance in gross margin over years and hence always appear in the model solutions. That differentiates the upland farm from the lowland farm.

Table 3.9: Farming patterns in different scenarios of the upland farm

	Unit	(VII) Plan with larger stall	(VIII) Plan with larger crop land	(IX) Plan with more off-farm labor	(X) Plan with mixed assump-tions
Total gross income	**PPP$**	**4801.8**	**4585.0**	**4472.3**	**6013.3**
Land					
Land for winter-spring rice	ha	0.108	0.216	0.108	0.216
Land for summer-autumn rice	ha	0.108	0.216	0.108	0.216
Land for cassava	ha	0.008	0.005	0.005	0.008
Land for corn	ha	0.087	0.186	0.091	0.182
Livestock					
Chicken	Head	44	22	22	44
Sow	Head	2	1	1	2
Fattener	Head	4	2	2	4
Weaner	Head	28	14	14	28
Labor					
Monthly endowment for all farming activities	MD	44.9	44.9	44.9	44.9
Labor for major farming activities in January	MD	22.1	35.2	19.2	38.2
Labor for major farming activities in February	MD	10.7	12.5	7.8	15.5
Labor for major farming activities in March	MD	4.0	3.7	2.5	5.1
Labor for major farming activities in April	MD	2.9	1.4	1.4	2.9
Labor for major arming activities in May	MD	21.3	19.4	13.5	27.1
Labor for major farming activities in June	MD	26.5	30.1	18.9	37.8
Labor for major farming activities in July	MD	8.7	8.3	5.6	11.3
Labor for major farming activities in August	MD	6.9	4.7	3.8	7.7
Labor for major farming activities in September	MD	2.8	1.4	1.4	2.8
Labor for major farming activities in October	MD	9.8	15.5	8.4	16.9
Labor for major farming activities in November	MD	15.5	7.7	7.7	15.5
Labor for major farming activities in December	MD	15.9	8.0	8.0	15.9
Hired labor	MD	0	0	0	0
Borrowing	PPP$	0	0	0	0

Source: Own calculations based on selected households in TVSEP Household surveys 2007-2013

The sensitivity analysis suggests that an optimal risk efficient farming pattern for the lowland farm should specialize in two seasons of rice and no livestock. The optimal pattern generates safer but much smaller gross margin than what is actually observed. This optimal pattern is much different from the actual one where risky activities are still carried out. Farm might increase its income by renting more land for cropping activities or searching for off-farm job opportunities for its seasonal underemployed agricultural labor. The potential income from off-farm employment could partly beside the borrowing finance the rental and crop production inputs. Regarding to the upland, the optimal crop portfolio should be more diverse, namely not only rice but also corn and cassava where corn gets higher priority than cassava. Chicken and pigs should also be included in the portfolio. Upland farm could increase income through enlarging livestock size and looking for off-farm employment opportunities.

3.7. Summary and Conclusions

This chapter aims to assess the impacts of climate-related risks on the production systems of farms households in two agro-ecological zones, namely the lowland and the upland in Thua Thien Hue province, Vietnam. In addition, an optimal adjustment of agricultural activities to climate risks and climate change in these two areas is targeted. In order to achieve these objectives, the chapter follows the typical farm theory in agriculture by constructing typical farms for two areas based on TVSEP five year panel data from 2007 to 2013. The analysis is conducted by means of an interdisciplinary approach, which combines OLS with mathematical programming,

Descriptive results point out that flooding, pests/livestock diseases, drought and coldness are the most common climate-related shocks experienced by farm households in both areas in Thua Thien Hue province where the upland farm self-report higher level of impact severity than the lowland farm. The regression results, however, do not reveal any significant evidence of regional differential in the impact of climate-related events on crop yields. These suggest that the upland farm had less ability and capability to cope with climate-related shocks and thus are more seriously affected by these shocks. Climatic extreme events, as expected, negatively affected crop production but the vulnerability to these risks is different among crops. Specifically, rice yield seems to be hit by more types of risks but with lower level of severity while corn and peanut yields are more heavily affected once extreme coldness occurred. The gross margins of both chicken and pig in the lowland areas vary substantially over years.

The results of the mathematical programming show that the existing farmer's plans differ from the risk efficient plans especially in case of the lowland farm. Due to the high level of risks of livestock production in the lowland areas, livestock activities do not appear in the risk minimized solution although they could generate a high source of income for the farm. The farming pattern, which ensures income safety for the lowland farm is the allocation of their resource on rice and corn cropping without livestock while for the upland farm should be rice, corn, cassava and livestock. In reality, farmers in this region engage in chicken and pigs farming apart from crop farming. This is because, on the one hand, farm households can make use of kitchen food waste as feed for chicken and pigs and on other hand these animals play an important role in social-cultural life of farmers in the region. Since there is a trade-off between safe income and high income in livestock production found in the lowland farm, farmers may prefer lower levels of risk aversion as assumed by the model in order to have a chance for a higher income. Another important finding from the mathematical programming is that regardless of lowland or upland, of actual production pattern or model solution pattern, agricultural labor was sizably underemployed especial in the off-farm seasons. Sensitivity analysis shows that the lowland farm households could increase their income through enlarging land for cropping rice and corn besides taking additional off-farm occupation. The land rental could be financed by additional off-farm income or borrowings. Upland farm can additionally expand stall capacity for more pigs and chicken.

Overall findings suggest that under climatic risks and climate change it is vital for farms in Thua Thien Hue to have relevant coping strategies so that the negative effects of extreme climate events could be lessened. This is especially essential in the upland areas where total farm income is lower and thus the occurrence of extreme events has severe impact on farm’s livelihood. Production risks and their negative impacts could be reduced if there existed risk management tools such as effective agricultural insurance programs. Implementation of routine livestock vaccination schedules to prevent diseases is highly recommended. These measures could assure farming patterns, which yield higher and safer income. Strategies also need to be developed to generate employment opportunities for farmers during the off-seasons. In order to relax land and cash constraints for farms, liberated rental land market should be promoted by land law and credit access from official lenders should be supported.

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Appendix

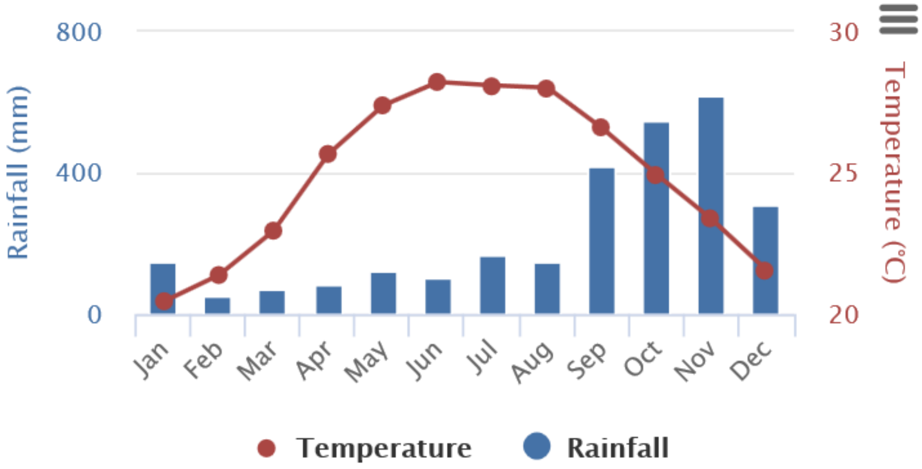


Figure A3.1: Average monthly rainfall and temperature for the lowland area at location (16.37,107.67), Thua Thien Hue province from 1991-2015

Source: The World Bank Group (2018)

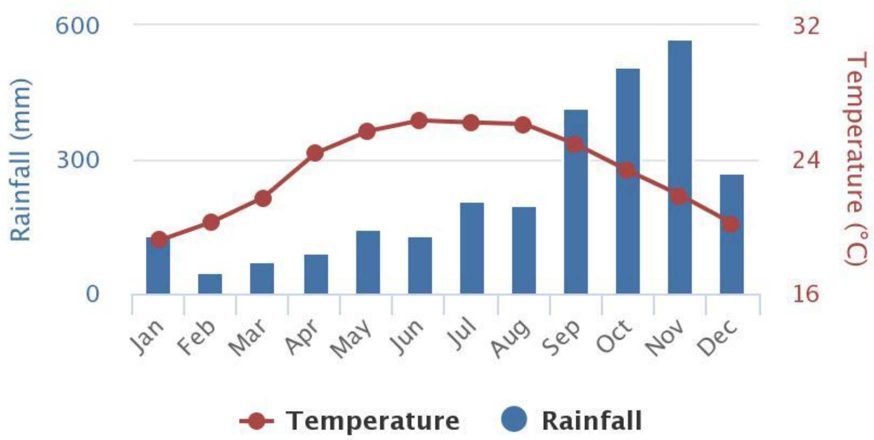


Figure A3.2: **Average monthly rainfall and temperature for the upland area at location (16.18,107.42), Thua Thien Hue province from 1991-2015**

Source: The World Bank Group (2018)

Table A3.1: Assessment of disaster severity in North Central Coast of Vietnam

Very severe	Severe	Medium	Low
Storm	Flash flood	Whirlwind	Desertification
Flood		Drought	
		Saline intrusion	
		Inundation	
		Landslide	
		Fire	
		Storm surge	

Source: Own compilation based on the National Report on Disaster Reduction in Vietnam (United Nations Office for Disaster Risk Reduction, 2005)

Table A3.2: Human and economic losses caused by natural disasters in Thua Thien Hue province from 1990-2006

Year	Human fatalities	Loss of asset (Billion VND)
1990	18	56.54
1991	10	20
1992	8	12
1993	6	13.54
1994	1	1.2
1995	20	60
1996	31	127.32
1997	1	10.92
1998	25	168.12
1999	352	1761.82
2000	5	73.6
2001	5	15.13
2002	9	15
2003	5	27.22
2004	10	248
2005	7	157
2006	8	2931.09

Note: 1000 VND is equal to 0.04 USD[9]
Source: Own compilation based on the report of Thua Thien Hue Centre for Hydro - Metrological Forecasting (2006)

[9] According to OANDA Currency Converter Exchange rate on 22/10/2018

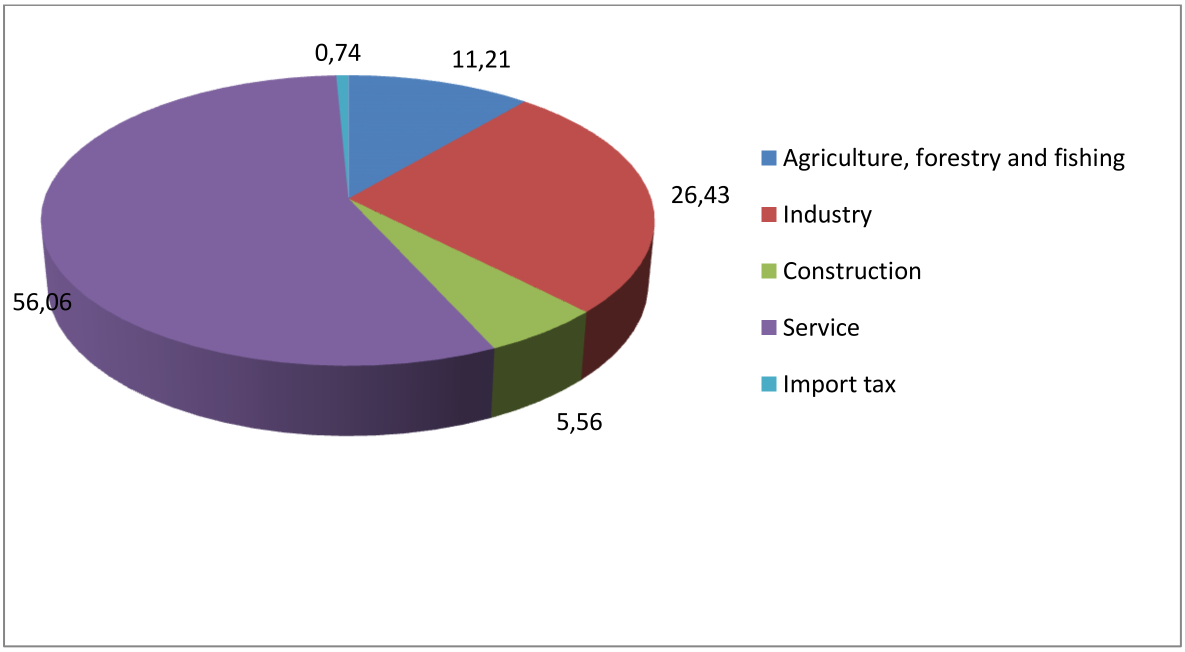


Figure A3.3: Provincial GDP by economic sector in Thua Thien Hue province in 2015 in percentage

Source: Own compilation based on the Statistical Yearbook of Thua Thien Hue 2016, pp.81 (GSO, 2017)

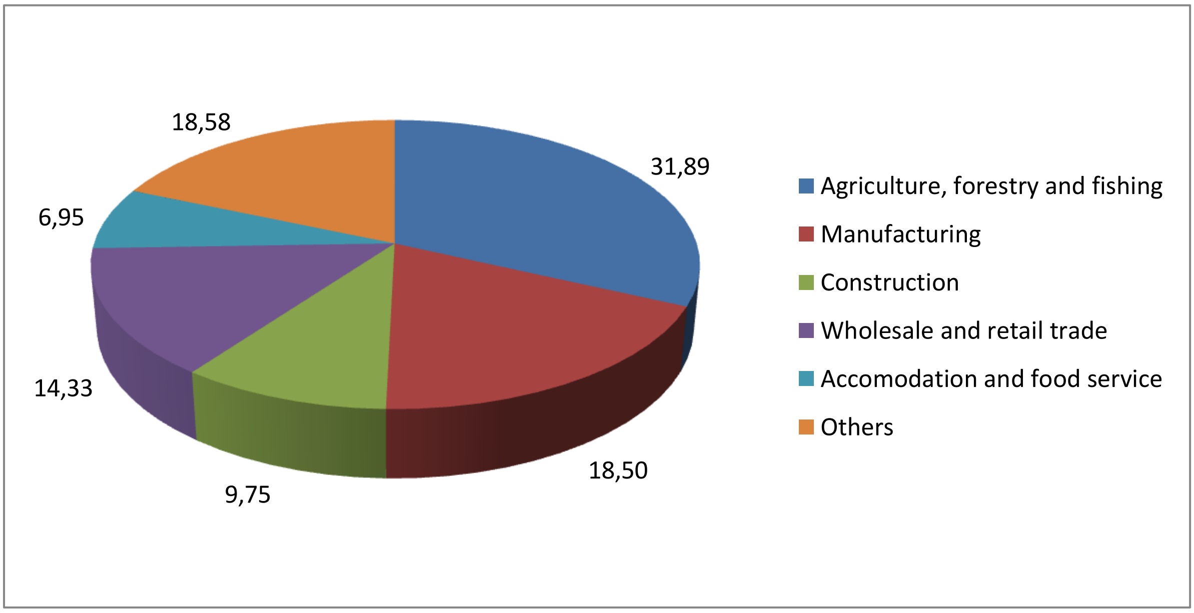


Figure A3.4: Structure of employment of Thua Thien Hue province in 2015 in percentage[10]

Source: Own compilation based on the Statistical Yearbook of Thua Thien Hue 2016, pp.71 (GSO, 2017)

[10] It counts labor at 15 years of age and above

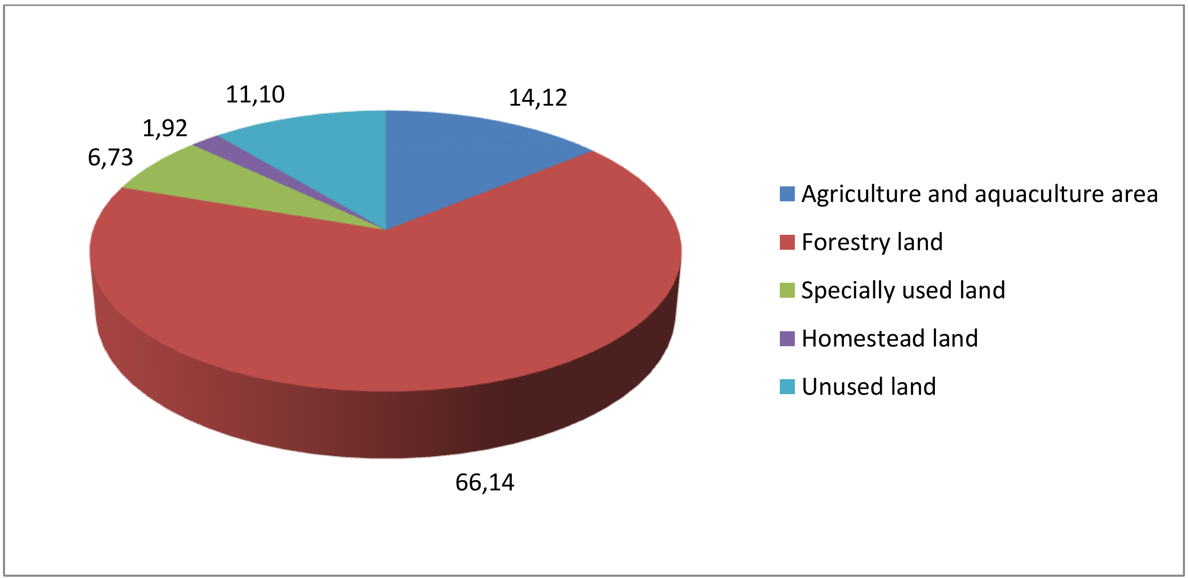


Figure A3.5: Structure of land of Thua Thien Hue province in 2015 in percentage[11]

Source: Own complication based on the Statistical Yearbook of Vietnam 2016, pp.32 (GSO, 2017)

[11] **Agriculture and aquaculture land** refers to the land used in agricultural production, including annual crop land and perennial crop land and land used in aquaculture.

Forestry land refers to the land with forests (included planted forests and natural forests) that meet the forest prescribed by the legislation on forest protection and development, and newly planted land or plantation forest in combination with natural farming

Specifically used land includes land used by the government offices, public services construction facilities; security and national defense land; land for non-agricultural production and business, and public land

Homestead land refers to land used for house and other works construction for living activities; garden and pond attached to house in a parcel of land in residential area (including garden and pond attached to detached house) which is recognized as homestead land. It includes land in urban and rural areas (General Statistics Office of Vietnam, 2017)

Table A3.3: Agriculture, forestry and fishing of Thua Thien Hue province in 2015

Activity	Unit	Amount
Agriculture	Billion VND	**4077.1**
Crop production		
Total gross output[a]	Billion VND	**2890.7**
Planted area of spring paddy rice	Thousand hectare	27.9
Planted area of autumn paddy rice	Thousand hectare	25.9
Planted area of winter paddy rice	Thousand hectare	0.6
Planted area of maize	Thousand hectare	1.6
Planted area of cassava	Thousand hectare	7.1
Yield of spring paddy rice	Ton per hectare	6.01
Yield of autumn paddy rice	Ton per hectare	5.82
Yield of winter paddy rice	Ton per hectare	1.67
Yield of maize	Ton per hectare	3.94
Yield of cassava	Ton per hectare	18.4
Livestock production		
Total gross output[b]	Billion VND	**969.8**
Pigs	Thousand heads	202.2
Poultry	Thousand heads	2093
Buffaloes	Thousand heads	20.6
Cattle	Thousand heads	22.1
Agricultural services[c]	Billion VND	**216.5**
Forestry[d]	Billion VND	**579.5**
Fishing[e]	Billion VND	**1939.5**
Aquaculture	Billion VND	1112.3
Fishery	Billion VND	827.2

Note: [a,b,c,d,e:] These values are measured at constant 2016 prices; 1000 VND is equal to 0.04 USD[12]
Source: Own compilation based on the Statistical Yearbook of Vietnam 2016, pp.170-202 (GSO, 2017) and Thua Thien Hue Portal (2018)

[12] According to OANDA Currency Converter Exchange rate on 22/10/2018

Chapter 4 : URBANIZATION AND CHILD MALNUTRITION: A COMPARISON OF THREE COUNTRIES IN THE GREATER MEKONG SUB-REGION

Abstract

Success in reducing monetary poverty in Southeast Asia has not fully translated into reduction in malnutrition. Using a two-year panel data from one province each in Thailand, Lao PDR and Vietnam, this essay studies the correlation between monetary poverty and nutritional outcomes of children under five. Furthermore, it compares nutritional outcomes of children below five between rural and peri-urban areas. It applies ordinary least squares and district fixed-effects regressions and finds that child nutrition remains a problem in rural areas across Southeast Asia despite achievements in poverty alleviation. Results reveal that although the households in the poorest quintile in both rural and peri-urban areas spend less on food; only the rural children are more likely to be stunted or underweight. It underscores the importance of investment in medical facilities near rural vicinities.

Keywords: poverty, child malnutrition, peri-urban, rural, Southeast Asia

4.1. Introduction

Thailand, Lao PDR and Vietnam are countries that belong to the Greater Mekong Sub-region (ADB, 2010). All have developed rapidly but at different starting points and with different rates of growth. Thailand has now reached the level of an upper-middle income economy. Vietnam has followed the growth path of Thailand after the impact of the *Doi Moi* policy reforms. Since about 2000 Vietnam had annual rates of economic growth in excess of 7% and has now reached the level of a lower-middle income country. Lao PDR has only recently opened its economy to private initiatives and foreign direct investments. As a result it is now achieving similar growth rates as the two neighboring countries but until now it is still one of the poorest countries in Asia (World Bank, 2017). However, monetary poverty has declined rapidly in the past decade in all the three countries albeit to different levels. The question that is of interest in this regards is to what extent reduction in monetary poverty has translated in the reduction of other types of poverty such as nutrition. Nutrition is of particular importance for the long term development success since malnutrition can negatively affect the outcomes of health and education. As shown by many literatures (Sen and Anand, 1997; Bourguignon and Chakravarty, 2003; Alkire and Foster, 2011; Ferreira, 2011) poverty is multi-dimensional and the correlation between reducing monetary poverty and non-monetary poverty measures is often low. A weak correlation between monetary poverty and nutritional poverty has been found in several empirical researches (e.g. Baulch and Masset, 2003; Haddad et al., 2003; Alderman et al., 2006).

It is well established that nutritional status during early stages of childhood has an impact on the physical, mental and social development of the child later on (UNICEF, 2016). Evidences show that the nutritional status of children in developing countries can vary considerably especially between urban and rural areas. The children in urban areas generally have a better nutritional status than their rural counterparts thanks to favorable socioeconomic conditions (Frankenberg et al., 1998; Garrett and Ruel, 1999; Smith et al., 2005; Fotso, 2007). However, there is a lack of understanding of the causes of differences in nutritional transitions and nutrition outcomes between rural and urban areas in the process of economic development. As countries grow formerly rural areas are urbanizing which leads to the emergence of the so-called peri-urban areas.

Hence, this study aims to fill this gap in literature and examines nutritional transitions in rural and urbanizing areas of Thailand, Vietnam and Lao PDR. The motivation in this study is to generate a better understanding of the nutrition transitions as these countries urbanize in the process of development. The study uses panel data from household survey carried out in 2011, 2013 and 2014 and apply a standard nutrition outcomes model.

Two major issues are found. First, in the course of development, households both, in urbanizing and in rural areas are spending less on food but the likelihood of stunting and underweight is significantly higher in the rural areas. Second, although poverty has declined to low levels in the three countries; malnutrition remains a problem even in Thailand, the most developed among the three countries in this study.

The chapter proceeds as follows. The next section outlines the methodology. The details of the study areas and the data collection procedure are discussed in section 3. Section 4 reports and discusses the results and section 5 concludes with some policy recommendations.

4.2. Empirical Strategy

Nutritional outcomes of children are widely assessed by age and gender standardized anthropometric indicators. The two most common anthropometric indices for accessing the nutritional status of children are height-for-age (HFA) and weight-for-age (WFA). These indices are interpreted according to the World Health Organization. Low height-for-age is indicator of stunting or shortness reflecting slowing in skeletal growth over a long period of time. A low height-for-age is usually caused by accumulated poor socioeconomic conditions or long-term nutritional deprivation. A low weight-for-age implies an existence of underweight and is generally associated with short-term dietary deficiencies. These indicators are commonly interpreted based on the Z-score classification system as defined by the World Health organization (WHO, 2016)[13].

This study uses the UNICEF framework (Ruel, 2008; UNICEF, 2013) to examine the drivers of malnutrition. The nutritional outcomes of children are determined by a set of immediate, underlying, and basic causes relating to biological, behavioral, and social aspects. Accordingly, child nutrition depends first and foremost on the food and nutrients that a child

[13] The Z-scores define anthropometric value as a number of standard deviations (SD) below or above the reference mean or median value of the WHO reference population. The prevalence of undernutrition is determined by the cut-off of < -2 SD.

takes as well as the child's health condition. These two determinants are placed as the immediate causes of child malnutrition. The framework also highlights the importance of the household's access to food, childcare practices, and water and sanitation services as underlying causes. Moreover, institutions, economic and political context together with environment constitute the basic component of childhood nutrition.

Following Becker (1965) and Strauss and Thomas (1995), this study uses household theory to establish causality between socio-economic conditions and malnutrition as household nutrition is also a component of its utility function, given its resource constraints and production choices. Thereby, a reduced form nutritional function derived from the household production function is applied to determine the nutritional outcomes of children under five (Glewwe et al., 2004; Alderman et al., 2006; Kabubo-Mariara et al., 2009; Waibel and Hohfeld, 2016) as below:

$$N_{it} = f(E_{jt}, C_{it}, M_{it,} H_{jt,}, \varepsilon_{it}) \quad (1)$$

where *t* stands for the time *(t=2011, 2013, 2014), i, j* respectively symbolize child *(i=1, 2,..,1345)* and household *(j=1,2,..., 1105). N* denotes the nutritional outcomes WFA and HFA Z-scores of the child indicating short-term and long-term nutritional status. *E* is the household's aggregate consumption per capita that includes expenditures of households on food, non-food, and housing related consumption in the preceding year. Consumption rather than income is used as the indicator of household wealth since consumption data are likely to be more accurate than income data in developing countries (Deaton, 1997; Glewwe et al., 2004). Moreover, consumption reflects long-term income stream and not just the income of the reference period (Haddad et al., 2003; Glewwe et al., 2004). *C* represents a vector of child characteristics such as age, health status and gender. *M* indicates a number of mother characteristics including age, nutritional outcomes, education and migration. *H* denotes household attributes like size, female headship, number of children under five, migration of other household members, access to tap water and sanitation, ε is randomly distributed error term.

In order to see the effects of food consumption on child nutritional outcomes, regressions of the per capita food expenditure on the same set of explanatory variables as in the equation 1 are subsequently run. The study begins the estimation with the ordinary least squares method

(OLS). Additionally, it also uses the district fixed-effects to estimate these two Z-scores in order to control for the unobserved and omitted heterogeneities across districts such as local health environment or locally implemented public health intervention programs.

4.3. Data and Study Areas

This study includes three provinces, namely Ubon Ratchathani in Thailand, Savannakhet in Lao PDR and Thua Thien Hue in Vietnam. These three provinces are geographically connected (ADB, 2010) and they are predominantly agricultural areas, albeit with quite different levels of development. Ubon Ratchathani is located in the northeast Thailand which formerly was the poverty pocket of Thailand. Recently the province has enjoyed rapid development with a well-developed road network and good accessibility to markets and public services. With a few exceptions, all districts in this province are urbanizing rapidly and therefore can be labelled as peri-urban. Savannakhet province is located to the northeast of Ubon Ratchathani and to its west shares the Mekong River as common with Thailand. Savannakhet is heterogeneous in terms of development and the degree of urbanization. The western part shows a similar degree of development as Ubon Ratchathani and therefore can be considered peri-urban. The central part of the province is still largely rural with poor roads and few infrastructures. It is similar with the eastern part which shares a common border with Vietnam. Finally, Thua Thien Hue province in Vietnam has a rapidly developing and urbanizing coastal and lowland area and a completely rural mountainous region which is bordering Lao PDR to its west.

The data used for Thailand and Vietnam are part of a research project called “Thailand-Vietnam Socio-Economic Panel” (TVSEP). For Lao PDR the panel data were collected as part of a research project on Food Security in Savannakhet. The surveys were conducted in different time periods. For Ubon Ratchathani and Thua Thien Hue, it took place in 2011 and 2013 while in Savannakhet it was conducted in 2013 and 2014. The total number of households in the panel in the three provinces is around 2,200. However, this study only includes households with children under the age of five. Hence the data base is composed of 1,105 households with 1,345 children under five from three provinces in three countries. The sample population is further grouped in urbanizing (peri-urban) and rural areas, i.e. there are three replications of peri-urban and two of rural areas in two years respectively in this study.

The sampling procedure differs for the three provinces due to the variation in the agro-ecological and institutional conditions (Hardeweg et al., 2013). A three-stage sampling method was applied in Thailand and in Vietnam while in Lao PDR a two-stage method was used (Parvathi and Nguyen, 2018). Furthermore, Ubon Ratchathani province (Thailand) was treated as a constituted stratum with a random selection of sub-districts as the primary sampling unit. In the first stage, sub-districts were selected with probability proportional to the population size. In the second stage, two villages were randomly chosen from each sampled sub-district. In the third stage, 10 households from each sampled village were selected systematically from a list of households ordered by household size with equal selection probability. This sampling method makes Ubon Ratchathani a self-weighted sample. Thua Thien Hue province (Vietnam) is characterized by diverse topography. Hence three strata representing three agro-ecological areas, namely coastal, lowland, and upland were specified in the first stage. The sampling procedure in each stratum of this province was similar to that in Ubon Ratchathani.

In the absence of a well-defined administrative structure and reliable baseline data in Laos, villages were used as the primary sampling unit. In the first stage, villages within the strata region were sampled. The probability of a village being chosen was proportional to its size. In the second stage the cluster size of 15 households per village in the western and central regions while 10 households per village in the eastern region were applied. Households were then selected randomly from the village lists.

In the surveys, comprehensive questionnaires were used consisting of several modules such as household members, health status, housing and sanitary conditions, assets, consumption expenditures and income generating activities, especially from agriculture and natural resources. The data on nutrition outcomes for children under five include age, gender, height and weight as well as health conditions during the reporting period and information on infrastructure conditions at village level was taken from a village head questionnaires which had been carried out in parallel to the household surveys.

4.4. Results and Discussion

The prevalence of poverty in the three provinces included in this study is shown by means of a cumulative distribution of per capita consumption subject to a poverty line of $1.25 (Figure 4.1a). Data from 2011 and 2013 for Thailand and Vietnam and data from 2013 and 2014 for Laos are pooled. The consumption ranking is shown in Figure 4.1a whereby there is an almost perfect stochastic dominance among the three provinces with poverty highest in Savannakhet and lowest in Ubon Ratchathani.

The differences in consumption among rural and peri-urban areas within the provinces of Thua Thien Hue and Savannakhet are shown in Figure 4.1b. Big gaps between peri-urban and rural areas in both Thua Thien Hue and Savannakhet are found. From the middle part of the distribution in Thua Thien Hue there is a convergence tendency between the two peri-urban and rural areas. This implies that the share of very rich households in the peri-urban area is not significantly different from the shares in the rural areas in this province in Vietnam. This difference is, however, not found in Savannakhet in Laos. Hence inequality in consumption is lower in Thua Thien Hue than in Savannakhet. Furthermore, it is striking to notice that the peri-urban areas in Thua Thien Hue and Savannakhet almost converge at higher levels of income indicating that at the higher end of the consumption distribution peri-urban areas in Laos and Vietnam are similar.

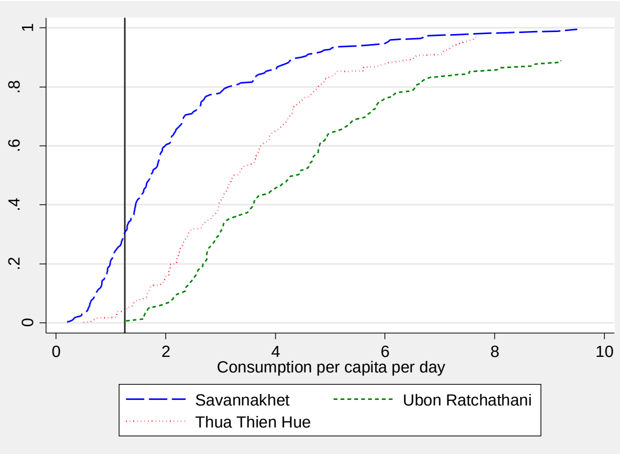


Figure 4.1a: Province-wise

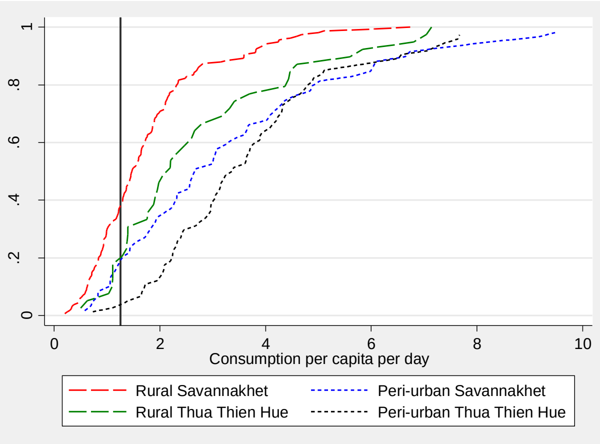


Figure 4.1b: Area-wise in Savannakhet (Laos) and Thua Thien Hue (Vietnam)

Figure 4.1: Cumulative distribution of consumption per capita per day

Source: Own calculations based on TVSEP and Lao Household surveys 2011- 2014

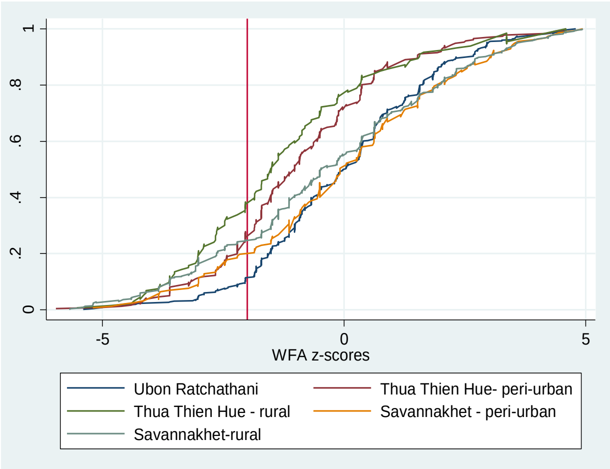
The major concern in this study is the nutritional outcomes of children less than five years in the three provinces in Thailand, Lao PDR and Vietnam. Comparing the nutritional outcomes among three provinces, the malnutrition rates (WFA and HFA), as expected, are found to be lowest in Ubon Ratchathani (Table 4.1). Specifically, with 10% underweight, this province can be regarded to have low underweight prevalence according to the WHO classification (WHO, 2010) while, with values larger than 20% Savannakhet and Thua Thien Hue are classified as areas with high prevalence of underweight. With regard to stunting, all three provinces from Thailand, Vietnam and Laos are characterised by very high prevalence rates.

Table 4.1: Child undernutrition by area, in percentage

Country (Province/Area)	**Underweight (WFA)**	**Stunting (HFA)**
Thailand (Ubon Ratchathani: Peri-urban)	9.83[a,b]	42.11[a,b]
Lao PDR (Savannakhet)	22.57[a,c]	59.19[a,c]
Peri-urban	19.85[d]	56.62
Rural	23.66[d]	60.21
Vietnam (Thua Thien Hue)	28.40[b,c]	58.10[b,c]
Peri-urban	27.38[e]	58.02
Rural	41.02[e]	58.97

Notes: The comparison is made by Pearson's chi-squared test, [a]$p<0.01$ for differences between Ubon Ratchathani and Savannakhet; [b]$p<0.01$ for differences between Ubon Ratchathani and Thua Thien Hue; [c]$p<0.05$ for differences between Savannakhet and Thua Thien Hue; [d]$p<0.1$for differences between peri-urban and rural in Savannakhet; [e]$p<0.1$for differences between peri-urban and rural in Thua Thien Hue
Source: Own calculations based on TVSEP and Lao Household surveys 2011-2014

The study examines the peri-urban and rural gap by investigating the anthropometric indicators in these two areas separately. The area-wise comparison shows that nutritional statuses of children in peri-urban areas are better than that in the rural area in underweight indicator. With reference to stunting, no significant gap is observed. These findings are further depicted in the distribution of the z-scores for WFA and HFA with the cut-off of -2 SD as shown in Figure 4.2a and Figure 4.2b. Although the gaps in WFA Z-scores between peri-urban and rural areas both in Savannakhet and Thua Thien Hue are larger than those for HFA, WFA gaps are smaller than the consumption gaps found in Figure 4.1b. This suggests that the big gaps in consumption do not translate into big gaps in nutritional outcomes of children across the three areas in these countries in Southeast Asia.



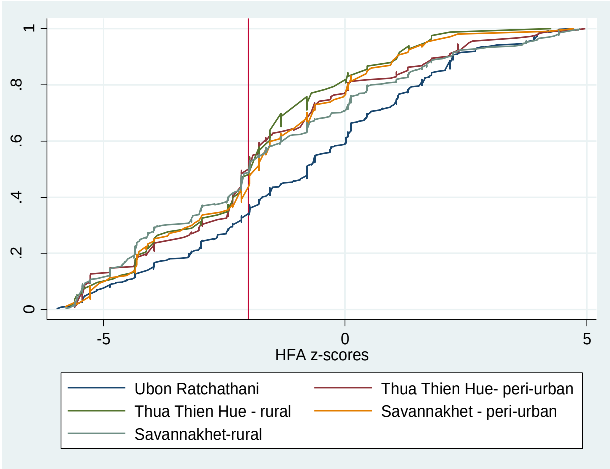


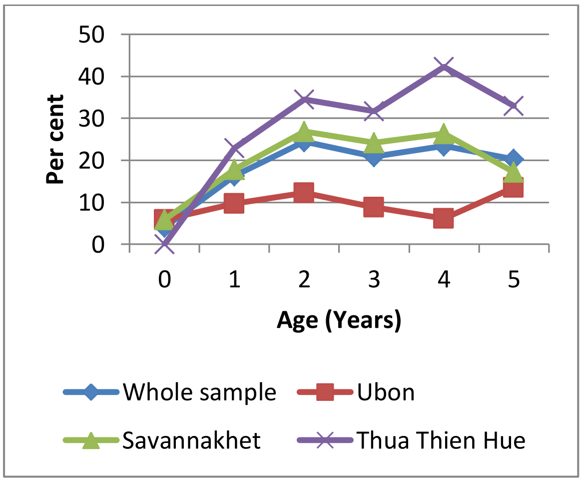
Figure 4.2a: Weight-for-age Z-scores **Figure 4.2b: Height-for-age Z-scores**

Figure 4.2: Cumulative distribution of child anthropometric Z-scores

Source: Own calculations based on TVSEP and Lao Household surveys 2011- 2014

This study also investigates child nutrition by age at the province level. The results for the underweight in Figure 4.3a demonstrate a similarity among all three provinces respectively in Thailand, Vietnam and Laos where children below one year are least likely to be underweight. This could be because they are largely dependent on breast feeding and mother´s nutritional inputs. Much variation in Ubon Ratchathani (Thailand) in the incidence of child underweight among different ages is found. Underweight rate fluctuates from around 6% for the age less than one until more than 13% for the age of five. In contrast, Savannakhet (Lao PDR) and Thua Thien Hue (Vietnam) show to have a considerable increasing trend of underweight children from birth to the age of two. Afterwards, the weight-for-age Z-scores improve slightly until children reach the age five. In Thua Thien Hue, however, an increase of underweight prevalence again for the age of four is found. The distribution for the whole sample shows a similar trend to Savannakhet.

Regarding stunting, Figure 4.3b shows similar shapes for all three provinces across the ages except for the peak at age five for Thua Thien Hue province. For the children from one to three years, the stunting incidence rises dramatically. For example, in Ubon Ratchathani the stunting rate was about 45% for age one and peaked with approximately 57% at age three. In Savannakhet, the stunting rates are even higher, around 64%. The prevalence in Thua Thien Hue ranges from around 56% to more than 63% for the age interval from one to three. By the age of four and five, the stunting rates decline in all three provinces except for the case of five years in the Vietnamese province of Thua Thien Hue.



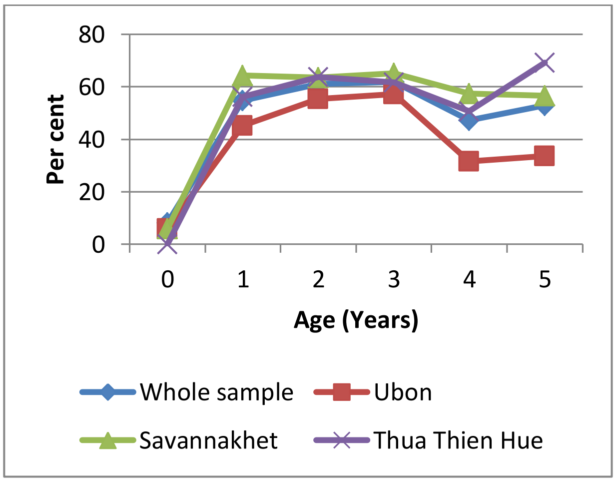


Figure 4.3a: Child underweight **Figure 4.3b: Child stunting**

Figure 4.3: Child undernutrition by age

Source: Own calculations based on TVSEP and Lao Household surveys 2011-2014

The study further investigates the nutritional outcomes of children by classifying them into moderate and severe malnourishment based on the threshold of –2 SD and -3 SD below the median of the WHO child growth standards, respectively (Table 4.2). The peri-urban and rural differences across the three countries are compared by means of Pearson's chi-squared tests. It is striking to note that regardless of child malnutrition indicators - underweight or stunting, and areas - peri-urban or rural, the severe undernutrition rates are much higher than the moderate undernutrition rates (except the underweight in the peri-urban). The gap is extremely large in stunting, especially in the rural areas. Table 4.2 also shows that there is no statistically significant difference across peri-urban and rural areas in terms of moderate undernutrition across the three provinces in Thailand, Vietnam and Laos.

Table 4.2: Child undernutrition severity by area, in percentage

Indicator	Moderate			Severe		
	Rural	Peri-urban	Difference	Rural	Peri-urban	Difference
Underweight (WFA)	9.04	9.60	-0.56	17.72	6.82	10.90***
	(28.70)	(29.47)		(38.22)	(25.22)	
Stunting (HFA)	9.94	11.74	-1.80	49.91	37.25	12.66***
	(29.95)	(32.21)		(50.04)	(48.37)	

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ of Pearson's chi-squared test, standard deviation in parentheses
Source: Own calculations based on TVSEP and Lao Household surveys 2011-2014

The relationship between undernutrition and wealth status of households are illustrated in Table 4.3. The wealth status is expressed by household aggregate consumption. Households are divided into five quintiles of consumption by province. As expected, children from wealthier households are less likely to be either underweight or stunted. This trend is consistent in Ubon Ratchathani and Thua Thien Hue. Also in Thua Thien Hue, children living in the poorest consumption quintile are more than twice as likely to be underweight and one point five times more stunted compared to children residing in the richest quintile.

Table 4.3: Child undernutrition by consumption quintile, in percentage

Country (Province)	**Consumption quintile**				
	1st	**2nd**	**3rd**	**4th**	**5th**
Thailand (Ubon Ratchathani)					
Underweight (WFA)	11.24	10.47	8.99	9.30	9.20
Stunting (HFA)	52.81	41.86	38.20	47.67	29.89
Lao PDR (Savannakhet)					
Underweight (WFA)	30.23	20.54	19.82	22.02	17.11
Stunting (HFA)	63.57	66.07	49.55	57.80	58.56
Vietnam (Thua Thien Hue)					
Underweight (WFA)	40.38	33.33	33.90	24.07	21.43
Stunting (HFA)	64.42	66.67	59.32	51.85	42.86

Source: Own calculations based on TVSEP and Lao Household surveys 2011-2014

In the next step the study investigates the differences in the socio-economic characteristics of the households between peri-urban and rural areas. The comparisons are made for the pooled data of three provinces across the three countries. If the characteristics are continuous and normally distributed, a t test to compare the means of those characteristics across peri-urban and rural areas is used. If the characteristics are continuous and not normally distributed, a Wilcoxon rank-sum test is applied to compare the sums of the ranks for observations from peri-urban and rural groups. In the case of dichotomous variable, a Pearson's chi-squared test is employed to compare the proportions of that variable between two groups. The test results with the significance level depicted by the number of asterisk are reported in Table 4.4.

The results show substantial differentials across peri-urban and rural households. For example, peri-urban household’s income is generated largely from small scale business but less from agricultural production as well as hunting, collecting activities whereas the rural household's income is other way around. The total consumption per capita including food and non-food expenses (for example health care, education, communication) of peri-urban households is remarkably higher than that of rural household.

Table 4.4 also reveals that children residing in peri-urban areas are less likely to get sick than those living in the rural regions. Regarding mother characteristics, the difference is particularly remarkable in the education level, where mother of a peri-urban child has more than six school years compared to almost three years in the rural. The nutritional outcomes in terms of the height of peri-uban mother also seem to be better than rural mother. Furthermore, women in peri-urban areas tend to migrate more than their rural counterparts.

Turning to other features of the household, it is found that the peri-urban women seem to have more intra-household decision-making power than the rural women. Specifically, in peri-urban areas around 23% of households are headed by women while only 9% of households in the rural areas have a female household head. Rural households tend to have more household members than peri-urban houses. On average, rural households have nearly one more member compared to their peri-urban counterparts. Furthermore, the dependency ratio is higher than that of peri-urban households.

Table 4.4: Comparison of characteristics between peri-urban and rural households

Indicators	Rural	Peri-urban	Difference
Income and consumption			
Share of agricultural income (%)	40.43	30.00	10.43 ***
	(35.19)	(32.37)	
Share of natural resource income (%)	27.51	9.63	17.88***
	(32.98)	(25.35)	
Consumption per capita per month (PPP$)	65.40	127.62	-62.22***
	(45.94)	(102.30)	
Food consumption per capita per month	42.22	65.67	-20.45***
	(28.68)	(41.28)	
Household engaged in small business (%)	13.78	41.22	-27.44***
	(34.51)	(49.26)	
Child			
Child is sick (%)	10.92	7.60	3.32*
	(31.23)	(26.52)	
Mother			
Age of mother (Years)	30.43	32.73	-2.3***
	(6.80)	(6.90)	
Height of mother (cm)	151.71	156.34	-4.63***
	(6.20)	(6.15)	

Education of mother (School years)	2.92	6.65	-3.73***
	(3.90)	(4.66)	
Mother migrated (%)	6.52	18.71	-12.19***
	(24.72)	(39.04)	
Household			
Household head is female (%)	9.02	23.25	-14.23***
	(28.69)	(42.27)	
Household size	6.42	5.57	0.85***
	(2.43)	(1.99)	
Dependency ratio (%)	118.59	89.15	29.44***
	(75.81)	(73.70)	
Migration of other members (Days)	139.72	282.18	-142.46***
	(247.95)	(284.46)	
Flush toilet (%)	5.46	22.95	-17.49***
	(22.75)	(42.08)	
Tap water (%)	25.18	54.82	-29.64***
	(43.45)	(49.80)	
Value of assets per capita (PPP$)	516.83	1,666.92	-1150.09***
	(741.97)	(2,982.00)	
Land per capita (ha)	0.10	0.36	-0.26***
	(0.30)	(0.47)	
Village			
Time to reach the next hospital (Minutes)	95.75	26.07	69.68**
	(153.95)	(13.90)	
Village with sanitation (%)	0.00	9.0	-9.06***
	(0.00)	(28.73)	
Village with public water (%)	31.12	77.19	-46.07
	(46.35)	(41.99)	

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$standard deviation in parentheses
Source: Own calculations based on TVSEP and Lao Household surveys 2011-2014

The peri-urban and rural differences are also found in the domestic sanitation facility and water supply. As expected, the proportion of households having a flush toilet is much higher in the peri-urban (nearly 23%) than in the rural areas (around 5%). Similarly, more than half of peri-urban households have access to tap water while only one-fourth of rural households do. The value of assets per capita and land endowment suggest that peri-urban households are much wealthier and possess more land than rural households. With reference to community attributes, rural residents are also at a disadvantage compared to peri-urban residents. For example, rural dwellers live much further from the hospital than the peri-urban dweller.

The determinants for nutritional outcomes of children under age five and household food expenses per capita are investigated by means of OLS and district level fixed-effects. The estimations are made on pooled data of rural children versus peri-urban children from the three provinces across the three countries. The panel data estimate is not applied since the estimate on the same children over years is quite problematic (Glewwe et al., 2004). The reason is that stunting and underweight prevalence as shown in Figure 3a and Figure 3b develop substantially in the first two years of life of children but afterwards change. Hence, the impact of household consumption which is classified in four quintiles on nutritional outcomes would be different for the children who passed the 2 year threshold in the second survey (2013 for Ubon Ratchathani in Thailand and Thua Thien Hue in Vietnam while 2014 for Savannakhet in Laos).

The determinants for weight-for-age Z-scores and height-for-age Z-scores are estimated separately but follow the same approach. Table 4.5 and Table 4.6 respectively illustrate the estimation results for child HFA and WFA Z-scores and household food consumption per capita for rural versus peri-urban areas. The results of OLS and the district level fixed effects are quite consistent although there are small differences in the magnitude of the coefficients and standard errors. It is found that although all the first three consumption quintiles in both rural and peri-urban areas spend significantly less on food expenses compared to the highest quintile, the rural children are significantly more stunted and underweight than peri-urban children irrespective of household consumption levels. It is also found that the effect of monetary poverty on child nutritional outcomes is somewhat clearly found in the rural households than in their peri-urban counterparts.

In both rural and peri-urban regressions, the coefficients of age and age squared show that as children grow older it is possible for them to improve their weight with adequate nutrition. This result is consistent with the findings of the study of Glewwe et al. (2004) in Vietnam and Kabubo-Mariara et al. (2009) in Kenya. The health condition of the child significantly influences his or her nutritional status. Specifically, on average a sick child has HFA Z-score around 1.6% less than the score of a healthy child. The statistically negative correlation of the sickness in the previous period of the child with the nutritional outcomes is supported by the nutrition framework of UNCEF (2013).

A significant correlation between mother’s height and her child’s nutritional outcomes is found. This result is in line with previous studies implying that the nutritional status of the child is influenced by mother’s nutritional outcomes (Glewwe et al., 2004; Alderman et al., 2006; Kabubo-Mariara et al., 2009; Waibel and Hohfeld, 2016). While some nutrition studies find that girls have lower nutrition outcomes than girls the (e.g., Sahn and Alderman, 1997; Kabubo-Mariara et al., 2009; Belitz et al., 2010), this is not necessarily the case for countries in Southeast Asia. For example, Glewwe et al. (2004) did not find any correlation between child gender and malnutrition status in Vietnam. This observation is confirmed in this study.

Regarding other household characteristics, the migration of household members (except for mother) has a positive effect on the height of children. This is however only found in the peri-urban area. It might be due to the fact that the peri-urban migrants do not go far as the urban areas are nearby and may have better communication with their households than the rural migrants. The positive effect of migration on nutritional outcomes can be explained through its positive effect on per capita calorie intake and household food diversity which is found in the studies of Antón (2010) and Nguyen and Winters (2011).

While the problem of underweight is less pronounced than stunting, similar results for the explanatory variables are found. The estimation results for WFA Z-scores in Table 4.6 are to some extent similar to those for HFA Z-scores as discussed above. Specifically, child's sickness in the past has significantly negative influence on the current WFA Z-scores. Migration of household members also positively affects the nutritional outcomes in terms of WFA Z-scores of peri-urban children. Different from HFA Z-scores, WFA Z-scores of children are not significantly influenced by mother's height. It is quite reasonable since HFA Z-scores is a pure long-term nutritional indicator while WFA Z-scores in indicator partly reflecting short-term changes (WHO, 1986).

In summary, the estimation results for HFA Z-scores and WFA Z-scores of children point out that child nutritional outcomes in Ubon Ratchathani (Thailand), Savannakhet (Lao PDR) and Thua Thien Hue (Vietnam) vary much by age of the child. The major determinants of outcomes both in rural and peri-urban areas include child health status and mother's nutritional status in terms of height although the magnitudes of their impacts are quite different across areas. The results also reveal two differences in the nature of determinants between rural and peri-urban areas. Firstly, aggregate household consumption has a greater effect on the child nutritional status in the rural areas than in the peri-urban area. Second, the migration of household members affects nutritional status of children in the peri-urban but not in rural areas.

Table 4.5: Rural vs. peri-urban regression on child height-for-age Z-scores

Variables	Rural				Peri-urban			
	Height-for-age Z-scores		Per capita food expenditure		Height-for-age Z-scores		Per capita food expenditure	
	OLS	FE	OLS	FE	OLS	FE	OLS	FE
Household wealth								
First quintile (Y/N)	-0.629*	-0.622***	-1.539***	-1.539***	-0.019	-0.028	-1.245***	-1.239***
	(-1.89)	(-3.87)	(-23.35)	(-25.74)	(-0.11)	(-0.15)	(-28.30)	(-18.68)
Second quintile (Y/N)	-0.319	-0.300*	-0.925***	-0.924***	0.306*	0.300*	-0.746***	-0.739***
	(-1.03)	(-1.81)	(-19.88)	(-24.52)	(1.91)	(1.76)	(-20.35)	(-13.56)
Third quintile (Y/N)	-0.463*	-0.444***	-0.502***	-0.500***	0.210	0.230	-0.456***	-0.452***
	(-1.80)	(-2.73)	(-10.56)	(-29.50)	(1.40)	(1.18)	(-11.57)	(-9.73)
Child Characteristics								
Child age (Years)	-1.529***	-1.528***	0.054	0.054	-0.609***	-0.605***	-0.064*	-0.065*
	(-7.03)	(-3.86)	(1.06)	(1.18)	(-3.28)	(-3.21)	(-1.84)	(-1.66)
Child age squared (Years)	0.212***	0.212***	-0.008	-0.008	0.066**	0.064**	0.010*	0.010
	(5.51)	(3.09)	(-0.92)	(-1.15)	(2.19)	(2.11)	(1.77)	(1.56)
Child’s sickness (Y/N)	-1.632***	-1.637**	-0.083	-0.083***	-0.885***	-0.868**	0.079**	0.089*
	(-5.07)	(-2.37)	(-0.72)	(-2.79)	(-2.82)	(-2.00)	(2.00)	(1.78)
Child girl (Y/N)	-0.112	-0.104	0.039	0.040	0.163	0.208	0.018	0.023
	(-0.64)	(-0.76)	(1.14)	(0.67)	(1.43)	(1.43)	(0.54)	(0.89)
Mother characteristics								
Mother’s height (cm)	0.018***	0.018	0.000	0.000	0.051**	0.056*	0.006	0.005
	(3.90)	(1.01)	(0.08)	(0.06)	(2.38)	(1.67)	(1.61)	(1.08)
Mother’s education (Years)	-0.024	-0.021	-0.006	-0.006	-0.007	-0.013	-0.002	-0.001
	(-0.73)	(-1.46)	(-1.06)	(-0.99)	(-0.50)	(-0.67)	(-0.80)	(-0.39)
Household characteristics								
Number of children under 5	-0.002	-0.007	-0.012	-0.013	-0.004	-0.004	0.017**	0.012
	(-0.04)	(-0.04)	(-1.47)	(-0.61)	(-0.12)	(-0.07)	(2.16)	(0.98)
Female headship (Y/N)	0.272	0.264	0.081	0.081	0.204*	0.104	0.015	0.020

	(0.70)	(0.56)	(1.12)	(0.67)	(1.66)	(0.50)	(0.51)	(0.46)
Migration duration (Days)	-0.025	-0.014	-0.007	-0.006	0.075**	0.085***	0.022***	0.020*
	(-0.29)	(-0.21)	(-0.49)	(-0.61)	(2.29)	(3.09)	(2.82)	(1.67)
Dependency ratio	-0.043	-0.052	0.051*	0.050*	0.029	0.016	-0.035	-0.029
	(-0.35)	(-0.23)	(1.73)	(1.91)	(0.32)	(0.15)	(-1.55)	(-1.31)
Share of agricultural income	0.032	0.023	0.052	0.052	-0.345	-0.405	0.209***	0.196***
	(0.10)	(0.10)	(1.04)	(0.75)	(-1.47)	(-1.46)	(4.76)	(3.42)
Flush toilet (Y/N)	0.434	0.458	0.172	0.181*	0.258	0.300	0.036	0.050
	(1.02)	(0.64)	(1.47)	(1.75)	(1.30)	(1.31)	(0.78)	(0.63)
Tap water (Y/N)	-0.180	-0.184	-0.015	-0.015	0.124	0.023	0.053**	0.063
	(-0.63)	(-0.81)	(-0.33)	(-0.32)	(0.87)	(0.12)	(2.24)	(1.29)
Climatic shocks (Y/N)	0.104	0.077	0.018	0.013	-0.217	-0.228	0.061**	0.056
	(0.49)	(0.18)	(0.55)	(0.18)	(-1.48)	(-1.38)	(2.13)	(1.44)
Country dummies								
Thailand (Y/N)					-0.177		0.013	
					(-0.88)		(0.34)	
Vietnam (Y/N)	-1.033***		0.116**		-1.187***		0.144***	
	(-3.02)		(1.99)		(-4.70)		(2.76)	
Intercept	2.511***	2.316**	4.116***	4.141***	0.066	-0.335	4.390***	4.462***
	(4.97)	(2.51)	(34.95)	(14.30)	(0.11)	(-0.37)	(45.73)	(34.71)
N	545	545	545	545	782	782	782	782
R- squared	0.171	0.129	0.690	0.686	0.142	0.099	0.615	0.613
P value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, t statistics in parentheses, [a]only children with a complete vector of explanatory variables are included in the regression
Source: Own calculations based on TVSEP Household surveys 2011-2014

Table 4.6: Rural vs. peri-urban regression on child weight-for-age Z-scores

Variables	Rural				Peri-urban			
	Weight-for-age Z-scores		Per capita food expenditure		Weight-for-age Z-scores		Per capita food expenditure	
	OLS	FE	OLS	FE	OLS	FE	OLS	FE
Household wealth								
First quintile (Y/N)	-0.588**	-0.577**	-1.555***	-1.555***	-0.043	-0.070	-1.250***	-1.244***
	(-2.45)	(-2.11)	(-23.01)	(-26.82)	(-0.26)	(-0.43)	(-24.88)	(-18.13)
Second quintile (Y/N)	-0.322	-0.299	-0.926***	-0.926***	0.312**	0.307	-0.746***	-0.739***
	(-1.20)	(-1.32)	(-18.24)	(-23.23)	(1.99)	(1.63)	(-17.97)	(-12.81)
Third quintile (Y/N)	-0.463*	-0.440	-0.508***	-0.505***	0.232*	0.248	-0.454***	-0.451***
	(-1.75)	(-1.52)	(-11.27)	(-28.27)	(1.68)	(1.32)	(-10.13)	(-10.36)
Child characteristics								
Child age (Years)	-1.489***	-1.487***	0.048	0.048	-0.625***	-0.614***	-0.063*	-0.064*
	(-6.79)	(-3.59)	(0.92)	(1.14)	(-3.40)	(-3.59)	(-1.68)	(-1.50)
Child age squared (Years)	0.205***	0.204***	-0.007	-0.007	0.068**	0.066**	0.010	0.010
	(5.55)	(2.87)	(-0.81)	(-1.06)	(2.31)	(2.31)	(1.64)	(1.44)
Child’s sickness (Y/N)	-1.668***	-1.674*	-0.086	-0.085***	-0.829***	-0.828**	0.080	0.090
	(-5.46)	(-1.70)	(-0.97)	(-2.93)	(-2.88)	(-2.04)	(1.62)	(1.22)
Child girl (Y/N)	-0.084	-0.075	0.036	0.037	0.192	0.234*	0.019	0.024
	(-0.50)	(-0.58)	(0.91)	(0.79)	(1.53)	(1.77)	(0.74)	(0.92)
Mother characteristics								
Mother’s height (cm)	0.000	0.001	-0.003*	-0.003	0.016	0.009	-0.003	-0.003
	(0.03)	(0.02)	(-1.91)	(-0.80)	(1.51)	(0.76)	(-1.13)	(-0.95)
Mother’s education (Years)	-0.023	-0.020*	-0.006	-0.006	-0.014	-0.020	-0.002	-0.002
	(-0.86)	(-1.80)	(-0.92)	(-1.06)	(-1.08)	(-1.11)	(-0.83)	(-0.49)
Household characteristics								
Number of children under 5	-0.013	-0.018	-0.011	-0.012	-0.010	-0.007	0.015**	0.011
	(-0.25)	(-0.12)	(-1.31)	(-0.79)	(-0.25)	(-0.11)	(2.23)	(0.99)
Female headship (Y/N)	0.260	0.250	0.090	0.089	0.153	0.062	0.012	0.019

	(0.87)	(0.45)	(1.23)	(0.78)	(0.86)	(0.32)	(0.34)	(0.41)
Dependency ratio	-0.052	-0.063	0.051**	0.051*	0.029	0.017	-0.035*	-0.029
	(-0.38)	(-0.21)	(2.41)	(1.87)	(0.34)	(0.16)	(-1.84)	(-1.30)
Share of agricultural income	-0.005	-0.017	0.057	0.058	-0.311	-0.370	0.211***	0.199**
	(-0.01)	(-0.12)	(1.23)	(0.76)	(-1.13)	(-1.46)	(4.56)	(2.40)
Migration duration (Days)	-0.026	-0.014	-0.008	-0.007	0.071**	0.079***	0.021***	0.020*
	(-0.37)	(-0.16)	(-0.65)	(-0.88)	(2.30)	(3.01)	(2.74)	(1.75)
Flush toilet (Y/N)	0.416	0.437	0.183	0.192**	0.257	0.304	0.041	0.055
	(1.19)	(0.63)	(1.40)	(2.55)	(1.56)	(1.18)	(1.16)	(0.76)
Tap water (Y/N)	-0.185	-0.190	-0.013	-0.013	0.146	0.042	0.053	0.063
	(-0.71)	(-0.84)	(-0.23)	(-0.26)	(1.25)	(0.22)	(1.59)	(1.44)
Climatic shocks (Y/N)	0.136	0.106	0.014	0.010	-0.214*	-0.225	0.060**	0.055
	(0.60)	(0.22)	(0.37)	(0.17)	(-1.71)	(-1.18)	(2.01)	(1.42)
Country dummies								
Vietnam (Y/N)	-1.088***		0.116*		-1.315***		0.127***	
	(-3.26)		(1.84)		(-6.31)		(2.62)	
Thailand (Y/N)					-0.224		0.021	
					(-1.03)		(0.49)	
Intercept	2.245	1.966	3.048***	3.061***	-1.222	-0.622	3.704***	3.770***
	(1.07)	(0.28)	(11.76)	(4.51)	(-0.69)	(-0.32)	(9.95)	(7.17)
N	545	545	545	545	782	782	782	782
R2	0.165	0.122	0.691	0.687	0.137	0.089	0.615	0.613
P	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, t statistics in parentheses, [a]only children with a complete vector of explanatory variables are included in the regression
Source: Own calculations based on TVSEP and Lao Household surveys 2011- 2014

4.5. Summary and Conclusions

Using a comprehensive household panel data from three provinces in Thailand, Lao PDR and Vietnam this essay examines the difference in nutrition poverty outcomes between rural and urbanizing areas in these three countries. The data set is believed to be representative for many of the fast growing countries in Southeast Asia. The study uses data from panel surveys and apply an ordinary least squares as well as district level fixed-effects regressions.

The most important finding of this essay is that malnutrition remains a problem in the growing economies of the three countries in both peri-urban and rural areas. Even in the province of Ubon Ratchathani in Thailand which is a rapidly urbanizing region with almost zero poverty and average per capita income (not including the provincial and district capitals) of over 3,000 PPP$, malnutrition remains a problem; although the situation is better than in the two provinces in Vietnam and Lao PDR, Thua Thien Hue and Savannakhet, respectively. As expected, malnutrition in rural areas is found to be worse than in the urbanizing regions. On the other hand, the rural-urban differences in the province of Thua Thien Hue (Vietnam) are less pronounced than expected. Between the two major nutrition outcome indicators, i.e. underweight and stunting; the latter is the bigger problem. Also undernutrition categorized as "severe" is high in all three provinces.

Another result is that Ubon Ratchathani is quite homogenous both in terms of monetary poverty and undernutrition. On the contrary, Savannakhet and Thua Thien Hue are heterogeneous between the peri-urban and rural areas. The heterogeneity in monetary poverty is larger than in undernutrition. Specifically, the rural areas in these two provinces are doing worse than the peri-urban area in improving the underweight of children. These findings highlight that although Thailand, Vietnam and Laos are at different stages of growth rural children are always more malnourished than their peri-urban counterparts.

A key insight is that irrespective of income levels rural children are more stunted and underweight than their urban counterparts despite both regions spending significantly less on food. Child health primarily drives child nutritional outcomes in both peri-urban and rural areas. Results imply that even though a peri-urban child can be sick it is less likely to be stunted or underweight contrary to rural sick children who are also prone to be malnourished. This implies that apart from nutrition access to medical facilities for children are vital for development. Moreover in peri-urban setting, social and extended family networks play a critical role in childcare; while in the rural areas mother`s nutritional outcomes largely determine child health.

Overall, findings show that success in reducing monetary poverty does not lead to the same degree of success in reducing nutrition poverty. To improve nutrition, other measures are necessary such as improving child health care facilities and household sanitation. Moreover, awareness needs be created to involve female members in intra household decision making in favor for child nutrition. Furthermore, the rural and peri-urban nutritional gaps need to be bridged. However, different strategies should be adopted to improve peri-urban and rural child nutrition. Cost-effective childcare services should be established in peri-urban areas and schemes need to be developed to build medical facilities to improve nutritional outcomes of children in rural areas.

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