Mountain agriculture, natural resource extraction and risk perception: Determinants of vulnerability to poverty in rural Vietnam

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Dipl-Ökonom Marc Völker
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Erstgutachter:	Prof. Dr. Hermann Waibel Institut für Entwicklungs- und Agrarökonomik Wirtschaftswissenschaftliche Fakultät der Gottfried Wilhelm Leibniz Universität Hannover
Zweitgutachter:	Prof. em. Dr. Erich Schmidt Institut für Umweltökonomik und Welthandel Wirtschaftswissenschaftliche Fakultät der Gottfried Wilhelm Leibniz Universität Hannover
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Zusammenfassung

Das Konzept der Vulnerabilität hat sich zu einem wichtigen entwicklungsökonomischen Forschungsgebiet entwickelt und somit zu zahlreichen Studien geführt, die darauf abzielen, Bestimmungsgrößen von Vulnerabilität zu identifizieren und die Rolle von verschiedenen ex-ante Risikomanagement- und ex-post Schockbewältigungsstrategien zu beurteilen. Trotz wichtiger Fortschritte in den verschiedenen Richtungen der Vulnerabilitätsforschung, verbleiben verschiedene offene Punkte. Insgesamt besteht die Notwendigkeit einer umfassenden Untersuchung von Vulnerabilität, die alle wichtigen Arten von Risikoquellen und Schocks umfasst, und das komplette Portfolio an Schockbewältigungs- und Risikomanagementstrategien welches Haushalten in Entwicklungs- und Schwellenländern zur Verfügung steht berücksichtigt. Analysen kovariater klimatisch bedingter Schocks und idiosynkratischer Gesundheitsschocks, welche derzeit in der Literatur verstärkt behandelt werden, müssen mit Untersuchungen ökonomischer Schocks, wie z.B. Preisfluktuationen, die weniger Berücksichtigung in der Literatur finden, kombiniert werden. Darüber hinaus sollten empirische Analysen des Schockbewältigungs- und Risikomanagementverhaltens auf der Grundlage gut fundierter theoretischer Rahmen beruhen. Des Weiteren müssen neue Ansätze entwickelt werden mit deren Hilfe es möglich ist die gut entwickelten Konzepte der Ökonomie der Armut und des Risikos in der Landwirtschaft zu integrieren.

Das Ziel dieser Arbeit ist es die Bestimmungsgrößen von Vulnerabilität von ländlichen Haushalten in Vietnam zu untersuchen. Ein besonderer Schwerpunkt wird dabei auf eine bestimmte agro-ökologische Zone gelegt, nämlich dem Hochland der drei im Annamitischen Hochland bzw. Küstenstreifen gelegenen Provinzen Dak Lak, Ha Tinh und Thua Thien Hue in denen die empirischen Daten gesammelt wurden. Während der Schwerpunkt auf Vietnam gerichtet ist, bringt ein Teil der Arbeit einen Vergleich mit ländlichen Haushalten in Thailand ein, durch den zusätzliche Schlussfolgerungen gezogen werden können. Die spezifischen Ziele der Arbeit sind: (1) Die Rolle der Nutzung von Waldressourcen als Bewältigungsstrategie von ländlichen Haushalten die unter den negativen Folgen verschiedener Arten von

Schocks leiden zu untersuchen; (2) Mittels mathematischer Programmierung einen normativen Ansatz zur Untersuchung von Vulnerabilität zu entwickeln. Dieser soll dazu genutzt werden können, alternative Methoden zu erschaffen mit deren Hilfe die Fragestellung beantwortet werden kann, ob eine Veränderung von Rahmenbedingungen, ausgelöst durch einen Anstieg der Preise von landwirtschaftlichen Inputs und Outputs, das Aktivitätsportfolio and Vulnerabilitätsniveau von typischen Agrarhaushalten verändert; und (3) zu untersuchen ob die Erfahrung klimatisch bedingter Schocks die Wahrnehmung diesbezüglicher Risiken verändert, und wie diese Wahrnehmung die Anwendung von ex-ante Risikomanagementstrategien beeinflusst.

Die in dieser Arbeit verwendeten Daten wurden im Kontext des Forschungsprojekts „Impact of shocks on the vulnerability to poverty: consequences for development of emerging Southeast Asian economies“ (DFGFOR756[1]) erhoben. In den Jahren 2007 und 2008 wurde eine ca. 4400 Haushalte in Vietnam und Thailand umfassende Panelerhebung durchgeführt. Zusätzlich wurde eine vertiefende Erhebung im Mai 2008 und Januar 2009 von einer Unterstichprobe der Haushalte im Hochland der Provinz Thua Thien Hue in Vietnam durchgeführt. Vervollständigt wurde die empirische Grundlage dieser Arbeit durch qualitative Daten die in Expertenbefragungen mit lokalen Mitarbeitern der Wald- und Landwirtschaftsbehörden im Hochland der Provinz Thua Thien Hue in Vietnam erhoben wurden.

Insgesamt bestätigen die Ergebnisse dieser Forschungsarbeit die Erkenntnis früherer Studien (World Bank 2003, World Bank 2008a), dass Vulnerabilität ein wichtiges Problem in ländlichen Gegenden Vietnams, und möglicherweise auch in ähnlichen Gebieten anderer Schwellenländer, darstellt. Da die Quellen von Vulnerabilität in Vietnam vielfältig sind, ist ein Bündel verschiedener Maßnahmen nötig um die Fähigkeit von Haushalten, Risiken zu handhaben und Schocks zu bewältigen, zu verbessern.

[1] DFGFOR756 ist eine durch die Deutsche Forschungsgemeinschaft (DFG) finanzierte Forschergruppe der Universitäten Gießen, Göttingen, Hannover und Frankfurt, sowie der Kasetsart University in Bangkok, Thailand, und dem Centre of Agricultural Policy in Hanoi, Vietnam. Weitere Informationen unter http://www.ifgb.uni-hannover.de/vulnerability.html oder http://www.dfg.de

In Kapitel 3 dieser Arbeit wird ein auf dem theoretischen Ansatz der „new home economics“ basierender theoretischer Rahmen zur Analyse der Auswirkungen verschiedener Arten von Schocks auf die Allokation von Arbeitszeit zur Nutzung von Waldressourcen vorgestellt. Die Ergebnisse der diesbezüglich durchgeführten empirischen Untersuchung deuten darauf hin, dass Haushalte im Annamitischen Hochland in Vietnam Waldressourcen nutzen um die negativen Folgen extremer Wetterschocks zu bewältigen. Jedoch kann ein solcher Zusammenhang nicht in Bezug auf Gesundheitsschocks nachgewiesen werden. Vor dem Hintergrund der Bemühungen Wälder zu erhalten um so öffentliche Güter die Wälder bereitstellen zu schützen, deutet dieses Ergebnis darauf hin, dass geeignete Interventionen der Regierung nötig sind um ein Gleichgewicht zu erreichen, dass von Armut bedrohten und Waldressourcen abhängigen Haushalten im Falle von extremen Wetterschocks die Möglichkeit erhält, Einkommen durch die Nutzung von Waldressourcen zu generieren und gleichzeitig ein nachhaltiges Management von natürlichen Ressourcen ermöglicht. Ansätze welche die Kontrolle des Zugangs zu Waldressourcen direkt an betroffene Gemeinden delegiert sollten weiter unterstützt werden, da vorläufige Anzeichen darauf hindeuten, dass diese zu einem verbesserten Management von natürlichen Ressourcen beitragen können. Die empirische Analyse der Nutzung von Waldressourcen als Schockbewältigungsstrategie kann weiter verbessert werden indem weitere Kontrollvariablen zur besseren Abbildung des haushaltspezifischen Zugangs zu Wäldern in entsprechenden ökonometrischen Modellen berücksichtigt werden.

Kapitel 4 demonstriert, dass normative mathematische Programmierungsmodelle typischer Agrarhaushalte ein nützliches ergänzendes Instrument zur Analyse von Vulnerabilität sind. Solche Modelle haben den Vorteil, simultan mehrere verschiedene Risikoquellen, wie z.B. Preisschwankungen und Wetterschocks, in einem konsistenten theoretischen Rahmen berücksichtigen zu können. Ergebnisse des auf eine bestimmte Gruppe von typischen Haushalten im Hochland der Provinz Thua Thien Hue angewendeten Modells deuten darauf hin, dass der Netto-Effekt des kürzlich beobachteten globalen Anstiegs der Preise für Nahrungsmittel und landwirtschaftliche Produktionsfaktoren, der im Jahr 2008 seinen Höhepunkt fand, auf das Einkommen negativ ist. Dieser negative Netto-Effekt liegt zum einen in dem gestiegenen Verbraucherpreis für Reis begründet und zum anderen darin, dass diese

Gruppe von typischen Haushalten nicht von dem gestiegenen Produzentenpreis für Reis profitieren kann, sondern von gestiegen Produktionskosten als Folge des ebenfalls gestiegenen Preises für chemische Düngemittel betroffen ist. Als Folge steigt das Risiko dieser Haushalte in Armut zu fallen.

Über diese Erkenntnisse hinaus, zeigt das Modellergebnis, dass nur Haushalte mit einer relativ geringen Risikoaversion in der Lage sind, ein risikoeffizientes Produktionsportfolio zu implementieren welches den negativen Effekt des Preisschocks zumindest teilweise mildert. Mehrere Einschränkungen werden aufgezeigt mit denen die Haushalte konfrontiert sind, z.B. eine beschränkte Ausstattung mit landwirtschaftlich nutzbarem Land, fehlender Zugang zu bestimmten Produktionsfaktoren und fehlende alternative Optionen zur Generierung von Einkommen. Weitere Untersuchungen sind nötig um die Ursachen solcher Eintrittsbarrieren zu effektivem Risikomanagement besser zu verstehen und geeignete Politikmaßnahmen zu empfehlen.

Die Flexibilität bei der Konstruktion typischer Haushalte eröffnet einen direkten Weg um individuelle Vulnerabilitätsniveaus einer Vielzahl von Haushaltstypen zu untersuchen, unabhängig von deren relativem Anteil an der Gesamtbevölkerung. Dadurch können Schlussfolgerungen bezüglich kleiner administrativer Einheiten getroffen werden, was anhand von positiven ökonometrischen Methoden aufgrund des Problems zu kleiner Stichproben schwierig wäre. Die Methodik kann ebenfalls genutzt werden um den Einfluss von Politikmaßnahmen und der Einführung neuer Technologien auf die Vulnerabilität von Haushalten zu analysieren. Es wird deshalb empfohlen, solche normativen Methoden für zukünftige Vulnerabilitätsstudien weiter zu entwickeln um ökonometrische Ansätze zu ergänzen.

Kapitel 5 untersucht den Zusammenhang zwischen der Erfahrung klimatisch bedingter Schocks, der diesbezüglichen Wahrnehmung von Risiken und der Anwendung von Risikomanagementstrategien. Die Ergebnisse zeigen, dass Informationskampagnen die darauf abzielen ländliche Haushalte in sowohl Vietnam als auch Thailand über mögliche Gefahren zu informieren auf ein generelles Bewusstsein dieser Haushalte im Hinblick auf verbreitete Risikoquellen bauen können. Jedoch werden Unterschiede in der Verarbeitung von Schockerfahrung in

Risikowahrnehmung bezüglich klimatisch bedingter Risiken zwischen den untersuchten Provinzen deutlich, welche politische Entscheidungsträger bei der Planung zukünftiger Risikoinformationskampagnen berücksichtigen sollten. Als weiterer Schritt wird empfohlen, die Auswirkung von Risikomanagementstrategien für klimatisch bedingte Schocks auf die Vulnerabilität von Haushalten zu schätzen, um so den Zusammenhang zwischen der Erfahrung klimatisch bedingter Schocks, der diesbezüglichen Wahrnehmung von Risiken, der Anwendung von Risikomanagementstrategien und transitorischer Armut besser verstehen zu können.

Schlagwörter: Armutsanfälligkeit, Berglandwirtschaft, Abbau natürlicher Rohstoffe, Risikowahrnehmung, Vietnam

Abstract

The concept of vulnerability to poverty has become an important subject for research in development economics and has motivated numerous studies that focus on identifying determinants of vulnerability as well as assessing the role of different types of ex-ante risk management and ex-post shock coping strategies. While there have been important advances in the different strands of vulnerability research, several major gaps remain. Overall, there is the need for a comprehensive assessment of vulnerability which includes all major sources of risk and shocks and accounts for the complete portfolio of shock coping and risk management strategies of households in developing and emerging market economies. The analysis of covariate climate-related shocks and idiosyncratic health shocks, which currently dominates the literature, needs to be combined with an assessment of economic shocks such as price fluctuations, which are only addressed by a small number of studies. Empirical analyses of ex-post shock coping and ex-ante risk management behavior should be based on sound theoretical frameworks. Furthermore, new approaches must be developed which can integrate the well-developed economics of poverty and risk in agriculture.

The objective of this thesis is to clarify some of the determinants of vulnerability to poverty among rural households in Vietnam. Hereby special emphasis is given to a particular agro-ecological zone namely the mountainous upland in three provinces of the Central Highlands and North Central Coast, namely Dak Lak, Ha Tinh and Thua Thien Hue, where the data have been collected. While the main focus of this thesis is on Vietnam, one part brings in a comparison with rural households in Thailand through which additional conclusions can be drawn. The specific objectives of the thesis are: (1) To assess the role of forest extraction as a coping strategy for rural households which are suffering from the negative effects of different types of shocks; (2) To develop a normative approach to vulnerability assessment by means of mathematical programming that can be used to test alternative methodologies for assessing whether a change in underlying frame conditions, triggered by a rise in prices of agricultural inputs and outputs, changes the activity portfolio and the

vulnerability level of typical farm households; and (3) To explore whether past climate shock experience shapes the perception of climate risk, and how such perception affects the use of ex-ante risk management strategies. The objectives are being dealt with in three different chapters which are actually individual papers one of which has been published in an internationally refereed journal.

The data used in this thesis were collected as part of the project "Impact of shocks on the vulnerability to poverty: consequences for development of emerging Southeast Asian economies" (DFGFOR756[2]). A two-period panel base survey was conducted in 2007 and 2008 among about 4400 households in six provinces in Thailand and Vietnam. Additionally, an in-depth survey was carried out in two waves in May 2008 and January 2009 among a sub-sample of households in the mountainous upland of Thua Thien Hue province, Vietnam. The empirical basis of this study was completed by qualitative data collected in expert interviews with local forest and agriculture officers in the mountainous upland of Thua Thien Hue province, Vietnam.

Overall, the results of this research confirm the results of previous studies (World Bank 2003, World Bank 2008a) that vulnerability to poverty is an important problem in rural Vietnam and, possibly, in similar emerging market economies. Since the sources of vulnerability among rural households in Vietnam are manifold, a set of measures aimed at improving risk management and shock coping abilities of households is needed.

Chapter 3 contributes a theoretical framework for the analysis of the effect of different types of adverse shocks on forest labor supply of households which is based on new home economics theory. Results indicate that households in the mountainous upland of Vietnam use forest products as a "natural insurance" when being affected by highly severe weather shocks. However, no such relationship is found for human health shocks. Against the background of forest protection efforts, that aim at protecting

[2] DFGFOR756 is a Deutsche Forschungsgemeinschaft (DFG)-financed collaborative research unit of the Universities of Gießen, Goettingen, Hannover, Frankfurt (all in Germany), Kasetsart University (Bangkok, Thailand), and the Centre of Agricultural Policy (Hanoi, Vietnam). For further information see:
http://www.ifgb.uni-hannover.de/vulnerability.html or http://www.dfg.de

public goods that forest provides, this outcome suggests that there is a need for suitable government interventions that can help to achieve a balance which leaves vulnerable, forest-dependent people the opportunity to generate income from forest extraction when being adversely affected by weather shocks, while enabling a sustainable management of natural resources. Community-based forest access control approaches should be further strengthened as there is preliminary evidence they can lead to an improved management of natural resources. The empirical analysis of forest extraction as a response to shocks may be advanced by adding further variables to the model which can better capture household-specific access to forest.

Chapter 4 demonstrates that normative mathematical programming models of typical farm households are a useful complementary tool in the analysis of vulnerability to poverty. They have the advantage to simultaneously account for multiple sources of risk, such as price fluctuations and weather calamities, in a theoretically consistent framework. Results of the model applied to a certain type of typical households in the mountainous upland of Thua Thien Hue province, Vietnam, indicate that the net-effect of the recent global price hike that arrived at its peak in 2008 on income is negative. This negative net-effect is due to the increased consumer prices of rice and because these type of households are not able to benefit from higher producer prices of rice, since no market exists for selling their produce, while suffering from increased costs of production as a result of higher prices of chemical fertilizers. As a result these households become more vulnerable to poverty.

It is shown that only households with a low level of risk aversion are able to implement a risk-efficient production portfolio, which mitigates the negative effect of the price shock to some extent. Several constraints are disclosed that households face such as a limited endowment with agricultural land, missing access to certain input factors and missing alternative options to generate income. Further investigation is needed to better understanding the underlying causes of such entry-barriers to effective risk management in order to guide suitable policy interventions.

The flexibility of constructing typical households provides a direct way to assess individual vulnerability levels for a multitude of household types regardless of their total share on population size. Hence, conclusions can be drawn for vulnerability

reduction policies of smaller administrative units which would be difficult with the use of positive econometric methods due to the problem of small sample sizes. The methodology can also be used to test the impact of policy interventions and the introduction of new technologies on vulnerability to poverty. It is therefore suggested to further develop such normative tools for future vulnerability analyses in order to complement econometric methods.

Chapter 5 explores the relationship between climate shock experience, risk perception and ex-ante risk management. Findings suggests that risk communication campaigns that focus on informing rural households about potential hazards can build on a general awareness of rural households in both Vietnam and Thailand about prevalent sources of risk. However, differences in the translation of risk experience into risk perception with regards to weather-related hazards between provinces indicate that policy makers should take inter-provincial differences in risk awareness into consideration when designing future risk information campaigns. As a further step it is recommended to estimate the effect of ex-ante climate risk management on the vulnerability to poverty of households in order to better understand the linkage between risk experience, risk perception, risk management and transient poverty.

Keywords: Vulnerability to poverty, mountain agriculture, natural resource extraction, risk perception, Vietnam

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List of abbreviations

ADB	-	Asian Development Bank
ALNAP	-	Active Learning Network for Accountability and Performance in Humanitarian Action
APF	-	Agricultural Production Function
ARF	-	Average Returns to Forest Extraction
CDF	-	Cumulative Distribution Function
DFG	-	Deutsche Forschungsgemeinschaft (German Research Foundation)
GDP	-	Gross Domestic Product
GSO	-	General Statistics Office of Vietnam
Ha	-	Hectare
IMF	-	International Monetary Fund
IPCC	-	Intergovernmental Panel on Climate Change
MARD	-	Ministry of Agriculture and Rural Development of Vietnam
MOTAD	-	Minimization of Total Absolute Deviations
NTFPs	-	Non-timber Forest Products
OLS	-	Ordinary Least Squares
PL	-	Poverty Line
PPP	-	Purchase Power Parity
UNDP	-	United Nations Development Programme
VBSP	-	Vietnam Bank for Social Policies
VBARD	-	Vietnam Bank for Agriculture and Rural Development
VND	-	Vietnamese Dong

Chapter 1

Introduction

1.1 Background of the study

Poverty is a scourge faced by too many people across the globe. The world's poor suffer from multiple dimensions of poverty, including malnutrition, ill health and poor education (Ellis 1984). Recent advances in the economics of poverty have helped to better understand the complexity of the poverty phenomenon in developing countries. Traditionally, in the field of development economics the well-being of people has been analyzed in a backward-looking way while disregarding future risks (Foster et al. 1984, Atkinson 1987, Ravallion 1993, Deaton 1997, Coudouel et al. 2002, Bourguignon and Chakravarty 2003). Based on such static assessments, it can be found that despite recent reductions in global poverty rates, by 2005, 1.4 billion people in developing regions lived on less than US$1.25 a day, which translates into 27% of their total population. About 830 million developing country residents were undernourished in 2005-2007 and one in four children was still underweight in 2008 (United Nations 2010).

However, results of such static poverty analyses can be misleading since they neglect the inherent uncertainty of economic outcomes and thus dynamic nature of poverty (Ravallion 1988, Calvo and Dercon 2007). In addition to those people in developing countries that are chronically poor, many more people are suffering from transient poverty or face the risk of falling into poverty in the future (Carter and Barrett 2006). In fact, consumption, an important indicator of well-being, is highly volatile in many developing country settings due to the adverse effects of demographic, social, economic, climatic and ecological shocks.

Alleviating transient poverty by supporting those who are vulnerable to poverty in addition to helping people who are chronically poor represents a challenge for local policy makers in developing countries, development practitioners and international organizations. Transient poverty has very different policy implications than chronic poverty (Elbers and Gunning 2003). Households which are vulnerable to poverty are in need of effective ex-post shock coping and ex-ante risk management abilities which can help them to either smooth their consumption after a shock event has taken place or to reduce the risk of being negatively affected by hardship before disaster strikes.

Vietnam is a typical example of a country where vulnerability to poverty represents an issue of importance. In spite of successful advances in overall poverty reduction, Vietnam faces a high degree of regional disparity in income and wealth with rural areas accounting for comparatively high rates of both chronic and transient poverty. A large share of rural households is still dependent on own agricultural production which thus continues to play an important role despite its declining share in gross domestic product (GDP). Nonetheless, non- and off-farm employment is increasingly used as an additional source of income (World Bank 2003, World Bank 2008b). Major risk factors for the rural areas in Vietnam are climate change, which among other effects lead to an increased frequency and severity of extreme weather events (ADB 2009a), and continued environmental degradation, which destroys natural resources that are crucial for the livelihoods of poor and vulnerable households, especially those living in remote, rural areas (World Bank 2005). Large-scale pest outbreaks like the brown plant hopper (Oerke 2006), and personal illnesses, injuries and deaths (Dercon 2002) add further burdens to the lives of the rural population. Being an emerging market economy, Vietnam is also increasingly prone to market shocks, such as rising commodity prices that adversely affect small-scale subsistence farm households, but also offer opportunities for producers of cash crops (Bresciani et al. 2002). Economic downturns, such as the 1997 Asian Economic Crisis or the recent global financial crisis, can affect non-agricultural activities of farm households when household members who are engaged in off-farm wage labor or non-farm self-employed are forced to migrate back to their rural place of origin (ADB 2009b) and to reduce the amount of remittances which they are sending to their family which lives in a rural area (Bresciani et al. 2002).

The concept of vulnerability to poverty, first introduced to a broad audience by the World Development Report 2000/2001 (World Bank 2001), has become an important subject for research. To effectively distinguish between households in transient and chronic poverty is a challenge which has been debated in the literature (e.g. Ravallion 1988, Jalan and Ravallion 2000, Justino and Litchfield 2003). Different methodological approaches for assessing vulnerability have been developed, including the concepts of v*ulnerability as expected poverty* (Pritchett et al. 2000, Chaudhuri et al. 2002), v*ulnerability as low expected utility* (Ligon and Schechter 2003) and v*ulnerability as uninsured exposure to risk* (Townsend 1994). Furthermore, Calco and Dercon (2005) have contributed an axiomatic approach to v*ulnerability to poverty*. Several empirical studies have applied these concepts in order to identify determinants of vulnerability to poverty and, thus, vulnerable parts of the population. For instance, Chaudhuri et al. (2002) used the concept of v*ulnerability as expected poverty* to assess household vulnerability to poverty in Indonesia while Tesliuc and Lindert (2004) estimated household vulnerability in Guatemala by applying the concept of v*ulnerability as uninsured exposure to risk*.

Other literatures have focused on ex-ante risk management and ex-post shock coping strategies. Ex-ante risk management strategies are implemented before a shock occurs in order to prevent the shock from occurring, or if prevention is not possible, to mitigate the adverse consequences of the risk (Dercon 2002, Alderman and Paxson 1994, Holzmann 2001). While ex-ante prevention strategies mostly comprise government policies such as investments in public health and education (Holzmann 2001), most ex-ante mitigation strategies fall into the domain of households and include, for instance, income diversification (Dercon 2002), livelihood diversification (Devereux et al. 2006) and income skewing, where households engage in activities of low risk but also low average return (Dercon 2002). Ex-post shock coping strategies are applied in order to smooth household consumption after a shock has occurred. Important ex-post shock coping activities include, for example, self-insurance by building up assets in good years which the household can deplete in bad years (Dercon 2004) and informal group-based risk sharing (Dercon 2002). Overall, the portfolio of theoretically available ex-ante risk management and ex-post shock coping strategies is manifold, however their application and effectiveness is often constrained by different factors including, for example, the lumpiness of assets, resource

constraints which the household faces and entry constraints to certain types of employment. Empirical studies have helped to assess the functioning of ex-post shock coping and ex-ante risk management strategies and the effect policy interventions could have on them (Dercon 2002).

While there have been important advances in the different strands of vulnerability research, several major gaps remain, some of which this thesis addresses. Overall, there is the need for a comprehensive assessment of vulnerability which includes all major sources of risk and shocks and accounts for the complete portfolio of shock coping and risk management strategies of households. The analysis of covariate ecological shocks and idiosyncratic health shocks, which currently dominates the literature, needs to be combined with a closer look at the impact of economic shocks, which are only addressed by a small number of studies (e.g. Bresciani et al. 2002, Justino and Litchfield 2003). Empirical analyses of ex-post shock coping and ex-ante risk management behavior should be based on sound theoretical frameworks (e.g. Rosenzweig and Binswanger 1993, Morduch 1995, Kochar 1999, Pattanayak and Sills 2001). Furthermore, new approaches must be developed which can integrate the well-developed economics of poverty (e.g. Ravallion 1993) and risk in agriculture (e.g. Andersen et al. 1977, Binswanger 1981, Dercon 2008, Hardaker et al. 1997), given the little attention which "has been given to the interface between these two fields of research" (Morduch 1994). In particular, mathematical programming models of farm households offer unique advantages due to their ability to integrate economic, biophysical and ecological elements of the farm, as well as the close connection between model components and real world constraints, thus capturing the complex and very interlinked nature of agriculture (Hardaker et al. 1997, Buysse et al. 2007). In addressing the mentioned research gaps, this thesis draws on a rich socio-economic dataset, specifically generated in order to overcome another weakness of current vulnerability research, which is the rather thin number of empirical datasets suitable for a comprehensive assessment of vulnerability.

1.2 Research objectives

The overall objective of this thesis is to analyze important components of vulnerability to poverty among agricultural households in three provinces in Vietnam, by exploring the role of various major sources of risk as well as the importance of different main strategies of ex-ante risk management and ex-post shock coping. This objective implies a number of issues which are addressed in three specific research objectives outlined below.

The first specific objective of this thesis is to assess the relationship between climate shock experience and climate risk perception of rural households in three Vietnamese provinces, Dak Lak, Ha Tinh and Thua Thien Hue, as well as the effect of climate risk perception on the use of ex-ante risk management strategies. Results of the analysis are compared to those derived from a corresponding analysis of data from three provinces in Thailand.

The rationale for the first specific objective is that rural households in Vietnam use a range of ex-ante risk management strategies in order to mitigate possible adverse effects of shocks in the future. Contrary to ex-post shock coping actions, ex-ante risk management is not triggered directly by the experience of shocks, but is rather a response to the perception of risk. Nonetheless, shock experience can indirectly trigger the use of ex-ante risk management strategies through its effect on risk perception. However, the role of experiential factors in risk perception, particular with regards to climate risk in developing countries, has only been explored in a small number of studies. At the same time, there are relatively few studies which explore the linkage between risk perception and the application of ex-ante risk management strategies.

The second specific objective of this thesis is to explore the role that forest products play as a natural insurance for rural households which are affected by adverse shocks. The analysis particularly focuses on the pattern of forest extraction, shock incidence and coping behavior in the mountainous upland of three Vietnamese provinces: Dak Lak, Ha Tinh and Thua Thien Hue. The main research question to be investigated is whether households in these areas extract more forest products when being affected

by two different types of shocks which are of major importance in that area: covariate weather calamities and idiosyncratic health shocks.

Since natural resources constitute an important asset for rural households in developing countries, part of this thesis focuses on the extraction of forest products, a common activity in Vietnam, particularly in mountainous upland areas. Forests have been described as providing a "subsidy from nature" of environmental goods serviced to households living on the forest margin which is free-of-charge (Anderson et al. 1991). However, despite a large bulk of scientific evidence on the general economic role of forest products for rural households in developing countries, evidence on its coping-mechanism role is far less pronounced and mostly available in the form of qualitative, ethnographic studies. Analyses which are based on empirical household-level models are comparatively rare and predominantly focus on rural forest in Latin America.

The third specific objective of this thesis is to develop a normative approach to vulnerability assessment by means of mathematical programming. This method can be used to test alternative methodologies for assessing whether a change in underlying frame conditions, triggered by a rise in prices of agricultural inputs and outputs, changes the activity portfolio and the vulnerability level of typical farm households in the mountainous upland of Thua Thien Hue province, Vietnam. The analysis is based on a mathematical programming model of typical farm households which allows for the interdependency of various agricultural and non-agricultural production elements, and to ensure the whole-farm objective subject to a set of resource constraints.

Contrary to common types of risk, such as severe weather conditions or human health shocks, which affect rural households on a regular, though unpredictable, basis, market shocks, such as the 1997 Asian Economic Crisis or the recent rise in global food prices, are a less common phenomenon particularly in remote rural regions where most production is being used for subsistence purposes and have, thus, received less attention in research. Assessing the effect of such rare events, about which little empirical data is available, on vulnerability to poverty can be facilitated by developing alternative vulnerability measures which can help to overcome some of the shortcomings of regression-based approaches. For example, regression-based

approaches lack the ability to model the behavioral response of households to changes in the underlying frame conditions of their economic functioning. Vulnerability measures which are based on a structural dynamic model of inter-temporal optimization under uncertainty have been identified as such an alternative (Elbers and Gunning 2003).

1.3 Outline of the thesis

This thesis is organized as follows:

Chapter 2 provides a description of the study area and the survey methodology applied to generate the dataset which forms the empirical basis of this study. In particular, it explains the general design of the study, the sampling procedure and the survey instrument, and gives information on the logistics and implementation of data collection. The chapter provides the base for the empirical applications in the subsequent chapters which are geared towards the three specific objectives described above.

Chapter 3 explores the "safety-net" role of rural forests in the mountainous upland of Dak Lak, Ha Tinh and Thua Thien Hue provinces. A household model of forest extraction under different shock scenarios is introduced from which hypotheses with regards to the response of households to both covariate weather and idiosyncratic health shocks are derived. After an assessment of the general pattern of forest extraction, shock incidence and coping behavior, these hypotheses are then tested by econometrically estimating a forest-labor supply equation under different shocks scenarios. The total sample size is 889 observations, which is reduced to 277 households in the regression models.

Chapter 4 employs a mathematical programming model of typical farm households in the mountainous upland of Thua Thien Hue province, in order to assess the effect of a price crisis on the activity portfolio of a typical type of household and its level of vulnerability to poverty. The analysis is based on a sub-sample of 22 households that belong to a group of 60 households which have been purposively selected to be

interviewed in an in-depth case study in addition to the broad socio-demographic household survey.

Chapter 5 contains a three-step regression approach in order to explore the links between climate shock experience, risk perception and ex-ante mitigation behavior. A sample of 2146 households in Dak Lak, Ha Tinh and Thua Thien Hue provinces is used as empirical basis of the empirical analysis. In the first step households' risk perception is explained by controlling for the short-term effect of weather-related and other shocks on households' risk expectations as well as for other socio-demographic factors that construct and maintain risk perception. The second step is to assess adoption and non-adoption of risk mitigation actions in general by applying a binomial logistic regression model. In the third step the likelihood of households taking up specific ex-ante risk management strategies with regards to their risk perception of climate risk is established.

The thesis closes with a synthesis of the previous chapters, summarizing the results, drawing conclusions and giving recommendations for policy makers and future research.

Chapter 2

Data and study sites

This chapter gives an overview of the data collection methodology which was employed in order to generate the empirical basis of this study. Following a description of the study area, a thorough explanation is given about the basic design of the study, the sampling procedure, the survey instrument and the implementation of the data collection process. The last section of the chapter presents some descriptive statistics in order to describe the sample households.

2.1 Study area

This study was conducted in Dak Lak, Ha Tinh and Thua Thien Hue provinces, Vietnam (see Figure 2.1 for a map of the study area). Dak Lak province is located in Vietnam's Central Highlands region and represents the country's largest province, covering about 19000 km². Ha Tinh and Thua Thien Hue provinces are situated in Vietnam's North Central Coast region, covering about 6000 and 5000 km², respectively. The three provinces were purposively selected for investigation based on the criteria of wide-spread poverty, agriculture dominating economic activity, emigration and cross-border trade. Thua Thien Hue province was given special emphasis in this research by collecting additional data from a smaller sub-sample of typical agricultural households in the mountainous upland.

The topography of the study area is diverse. On the one hand, Dak Lak province forms a large basin which, despite belonging to the Central Highlands, mainly lies between 200 m and 400 m above sea level (Brickle et al. 1998). On the other hand, Ha Tinh and Thua Thien Hue provinces can be divided into three main agro-ecological zones. While, in general, the altitude decreases from the mountainous upland with altitudes of up to over 2000 m in the West to the lowland plains to the coastal areas in

the East, the upland terrain is steep and strongly dissected into mountainous, hilly and plain areas (Nguyen 2008, World Bank 1999).

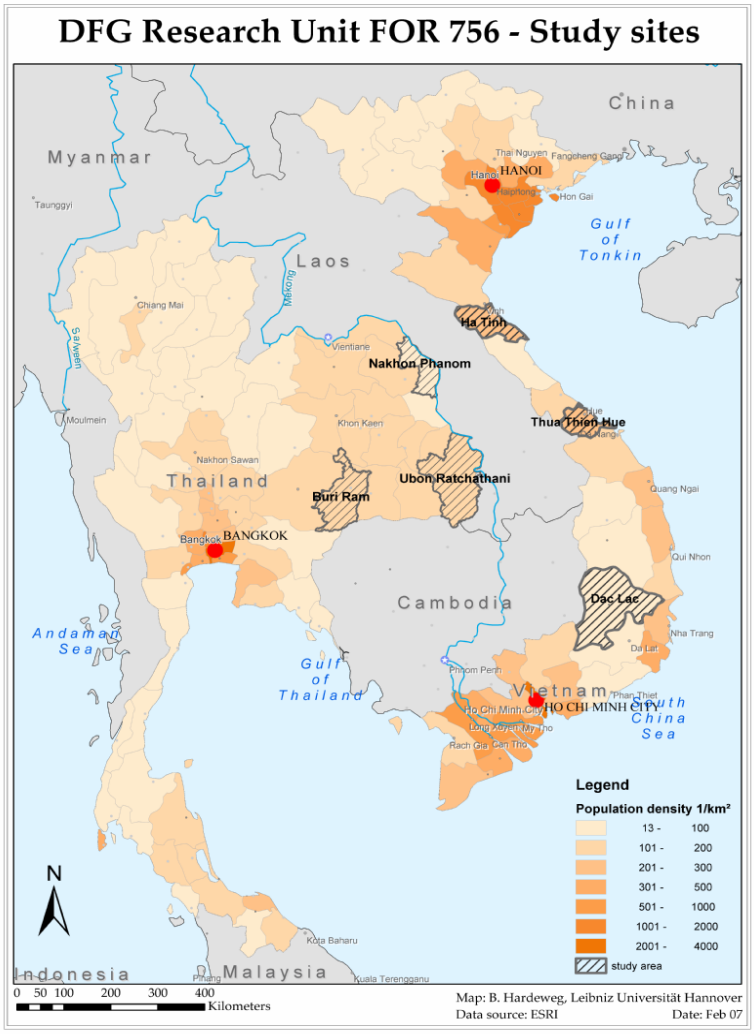

Figure 2.1: Map of South-East Asia showing the study areas of the DFG research unit FOR756

Source: ESRI, adapted by B. Hardeweg, Leibniz University Hannover.

Climatically, the study area is influenced by hot and humid weather as it is located in the tropical monsoon region. In Dak Lak, the mean precipitation is between 2000 and 2500 mm per year with more than 80% concentrated in the rainy season which lasts from May to November (World Bank 2005). Heavy rainfall occasionally causes inundation of land, such as flash floods in 2003, reported by the United Nations Development Programme (UNDP)/Ministry of Agriculture and Rural Development of Vietnam (MARD) Disaster Management Unit, which killed six people and destroyed

considerable areas of paddy. In the dry season, long droughts are common, such as a five-month drought in 2003 reported by the same unit which damaged large areas of cropland (Lindskog et al. 2005). In Ha Tinh and Thua Thien Hue, average annual rainfall is about 2500 mm with more than 85% of the rainfalls occurring during the rainy season from June to December. Ha Tinh and Thua Thien Hue provinces are frequently affected by an intertropical convergence zone which triggers tropical low pressures and typhoons, which occur particularly in October and November. Severe floodings in the wet season and droughts in the dry season are a repeatedly occurring consequence of the unequal distribution of rainfall (Nguyen 2008, World Bank 2005). The coastal plains are particularly susceptible to flooding due to their minimum slope (Villegas 2004), while the mountainous upland, due to the large zones of shrubs and bare hills, faces a high risk of soil erosion and landslides which is aggravated by an ongoing clearance of forests (Nguyen 2008).

Socio-economic conditions in the three study provinces are similar in many aspects, such as the relatively high incidence of poverty (Minot et al. 2003), though some peculiarities exist. Dak Lak is one of Vietnam's most forested provinces (Brickle 2002), and has a comparatively low mean population density of 135 persons per km² in the year 2008 (GSO 2010). Its approximately 1.8 million inhabitants (GSO 2010) are unevenly distributed across the province with a relatively high population density in the central and eastern districts (Brickle et al. 1998). The population, of which about 78% lived in rural areas in 2008 (GSO 2010), comprises 36 ethnic groups with 65% of the population belonging to Vietnam's ethnic Kinh majority. Due to its favorable agro-ecological conditions and high availability of land, Dak Lak has experienced strong immigration during the last 30 years (Caspersen 1999).

Farming is the main activity in Dak Lak, which has a long tradition of coffee cultivation (Caspersen 1999). Being situated in the Central Highlands, the ecological conditions in Dak Lak are particularly suitable for perennial tree crops (World Bank 2005). During the coffee boom in the 1990s, the area allocated to coffee cultivation expanded rapidly and virtually everybody, both rich and poor, benefited from the high prices of coffee. However, as coffee prices started to fall dramatically after some years, households, particularly those with a low level of resilience, suffered from the aggressive coffee expansion (Lindskog et al. 2005). Besides crop cultivation, forestry

is an important activity in Dak Lak. Both widespread commercial logging and the rapid expansion of agricultural land have taken their toll on large parts of the original forest in the province (Brickle et al. 1998).

Ha Tinh province had a total population of about 1.3 million with an average population density of 217 persons per km² in the year 2008. About 87% of its inhabitants live in rural areas with agriculture being the main economic activity (GSO 2010). The total population size of Thua Thien Hue province was about 1.2 million with a mean population density of 227 persons per km². The rural parts of the province were home to about 42% of its inhabitants (GSO 2010). The relatively high share of urban population in Thua Thien Hue province is mostly situated in and around the province's infrastructural and industrial center Hue City (Rutter 2001).

Ha Tinh and Thua Thien Hue provinces share a similar pattern of agro-ecological conditions. The lowland plains are suitable for annual crops contingent upon the availability of irrigation water. However despite a relatively developed irrigation system there is frequently not enough water for two rice cropping seasons, so that some farmers grow crops that require less water, such as peanut and corn. Livestock production in the lowlands is intensive and commercialized with conditions more suitable for pig and poultry production than for ruminant livestock. Agro-ecological conditions in the mountainous upland, which is the focus of the analyses presented in chapters 3 and 4, are less favorable. Ethnic minorities in the uplands predominantly rely on sloping agriculture and forestry (World Bank 2005). While the traditional practice in some upland areas has been slash-and-burn farming, the government has initiated a shift to sedentary farming, which has become the common practice, in order to tackle the problem of land scarcity. Farmers who changed their agricultural practices to sedentary farming are facing multiple problems, including a lack of familiarity with and knowledge about the new production technique, and poor access to input factors, which cause a low productivity (Vernooy 2006). A further general problem is the low soil fertility that is due to high water runoff that continuously removes soil nutrients. People in these areas often grow cassava and tree crops (e.g. rubber, cinnamon) or forests (e.g. eucalyptus, pine trees). With regards to livestock production in the mountainous upland, conditions are most suitable for large and small ruminants and village poultry. Due to the limited access to commercial feeds,

markets and strong support services livestock in the uplands is raised by using traditional or at best semi-intensive husbandry methods. Along the central coast line, marine and coastal aquaculture and industries are being developed. As the quality of local natural seawater is exceptionally high in the Central Coasts, it is the area where most shrimp hatcheries and nurseries are situated in Vietnam (World Bank 2005).

2.2 Study design

The data that form the empirical basis of this study were gathered as part of the project "Impact of shocks on the vulnerability to poverty: consequences for development of emerging Southeast Asian economies" (DFGFOR756[3]). A two-period panel base survey was conducted in 2007 and 2008 among about 4400 households in six provinces in Thailand and Vietnam (Figure 2.1). This study focuses on the data collected from the three Vietnamese provinces: Dak Lak, Ha Tinh and Thua Thien Hue. Chapter 5 is a joint work with Songporne Tongruksawattana, Institute of Development and Agricultural Economics, Gottfried Wilhelm Leibniz University Hannover, and entails, in addition to the analysis of the data collected in Vietnam, a cross-country comparison with the three Thai provinces: Buri Ram, Nakhon Phanom and Ubon Ratchathani. The surveyed households are representative of the rural population in these provinces. The two-period panel base survey produced a unique dataset of households' socio-economic characteristics, resource base, income-generating activities, sources of finance, shock experience and risk perception. The household survey was accompanied by a village head survey which was conducted in 2007 among the heads of all household survey villages.

Additionally, an in-depth survey was carried out in two waves in May 2008 and January 2009 among a sub-sample of households in the mountainous upland districts of Thua Thien Hue province: A Luoi and Nam Dong (Figure 2.2). This in-depth survey aimed at collecting complementary information on the consumption-production situation and decisions of farm households, including existing options and

[3] DFGFOR756 is a Deutsche Forschungsgemeinschaft (DFG)-financed collaborative research unit of the Universities of Gießen, Goettingen, Hannover (all in Germany), Kasetsart University (Bangkok, Thailand), and the Centre of Agricultural Policy (Hanoi, Vietnam). For further information see: http://www.ifgb.uni-hannover.de/vulnerability.html or http://www.dfg.de

restrictions, and shocks that had occurred in the past. The additional data were required for running the mathematical programming model of typical farm households which is presented in chapter 5 of this thesis. Finally, the empirical basis of this study was completed by qualitative data collected in expert interviews with local forest and agriculture officers in the mountainous upland of Thua Thien Hue province.

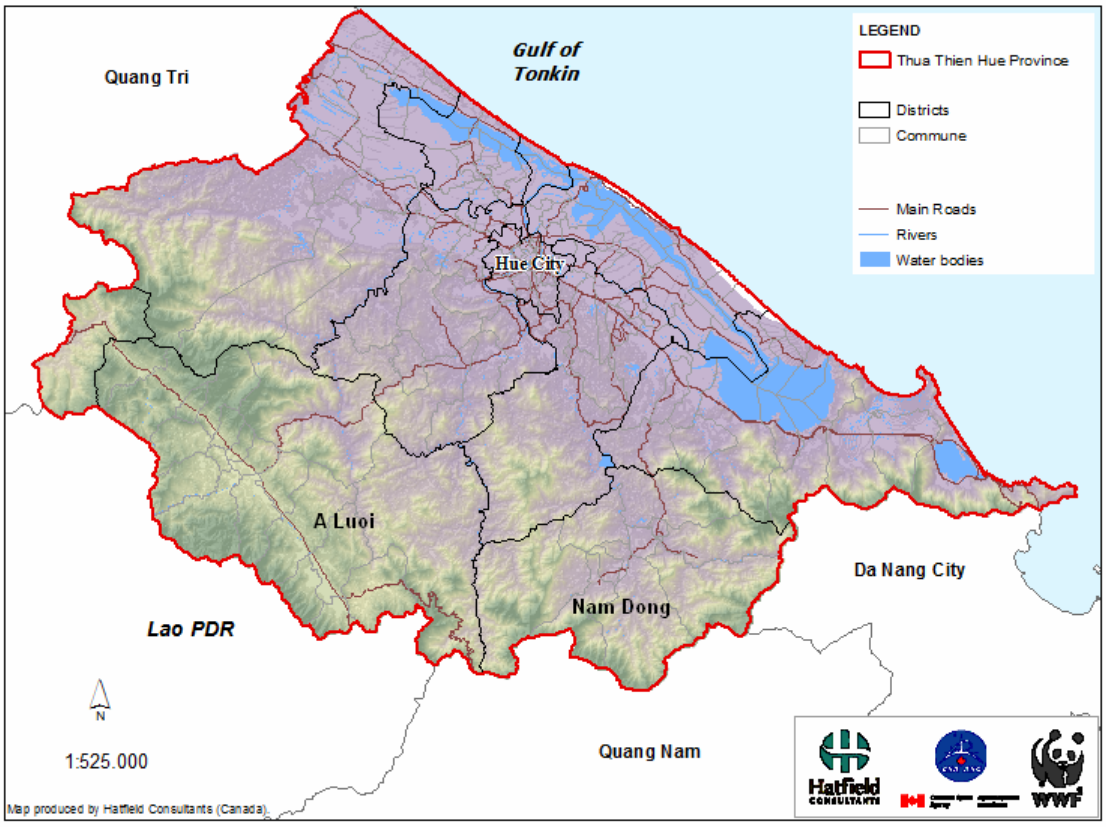

Figure 2.2: Map of Thua Thien Hue province showing the study area of the in-depth survey

Source: Adapted from Green Corridor Earth Observation and Geographic Information Toolkit, http://www.huegreencorridor.org/toolkit/

2.3 Sampling

The selection of households that participated in the surveys was conducted by two complementary approaches. While households which participated in the two-period panel base survey were randomly chosen based on a 3-stage stratified cluster sampling approach, the sub-sample of households interviewed in the in-depth survey was purposively selected.

2.3.1 Base survey

Obtaining a representative sample of the target population of rural and peri-urban households was the overall objective of the sampling design. Due to budget constraints, the total Vietnamese sample size was limited to 2200 households. In order to account for the heterogeneity in geographical conditions, strata were defined as agro-ecological zones within the purposively selected provinces in the first stage of the sampling procedure. Because of significant differences in size between these strata, an equally distributed allocation of the 2200 sample households would have resulted in inadequate total sample sizes in some of the strata. Therefore, different sampling rates were applied in the strata. However, in order to enable meaningful empirical inferences for each stratum, the respective minimum total sample size was set at 160 households (Hardeweg et al. 2007).

In the first stage of the sampling procedure 110 sub-districts were selected by means of systematic random sampling so as to reduce the geographical dispersion of the sample villages, and thus to contain travel costs, as well as to ensure proportional coverage of areas with relatively high (peri-urban) and low (rural) population density. In the second stage of the sampling procedure two villages from each of the selected sub-districts were sampled with probability proportional to size. The third stage again employed a systematic random sampling approach through which a fixed size sample of 10 households per village was selected systematically with equal probability from household lists ordered by household size. Hence a maximum of variation within each cluster could be achieved. Household lists and local administrative units were obtained from the Agricultural and Rural Census 2006 which had been conducted by the General Statistics Office of Vietnam (Hardeweg et al. 2007).

2.3.2 In-depth survey

As study area for the in-depth survey, the mountainous upland of Thua Thien Hue province was purposively selected on completion of the first wave of the two-period panel base survey. Results from the first wave of the two-period panel base survey had indicated that this region is particularly suitable for a vulnerability analysis of farm households since the major share of its population is made up of households which are predominantly engaged in agriculture, often poor and frequently affected by shocks. Decreasing the geographical scope of the analysis furthermore reduced the heterogeneity of natural frame conditions to a manageable level. A sub-sample of 60 households from the mountainous upland of Thua Thien Hue province, which are supposed to be indicative for the prevailing structure of farm households in the research area, were purposively selected. Figure 2.3 gives an overview of the ad hoc criteria employed in selecting these households.

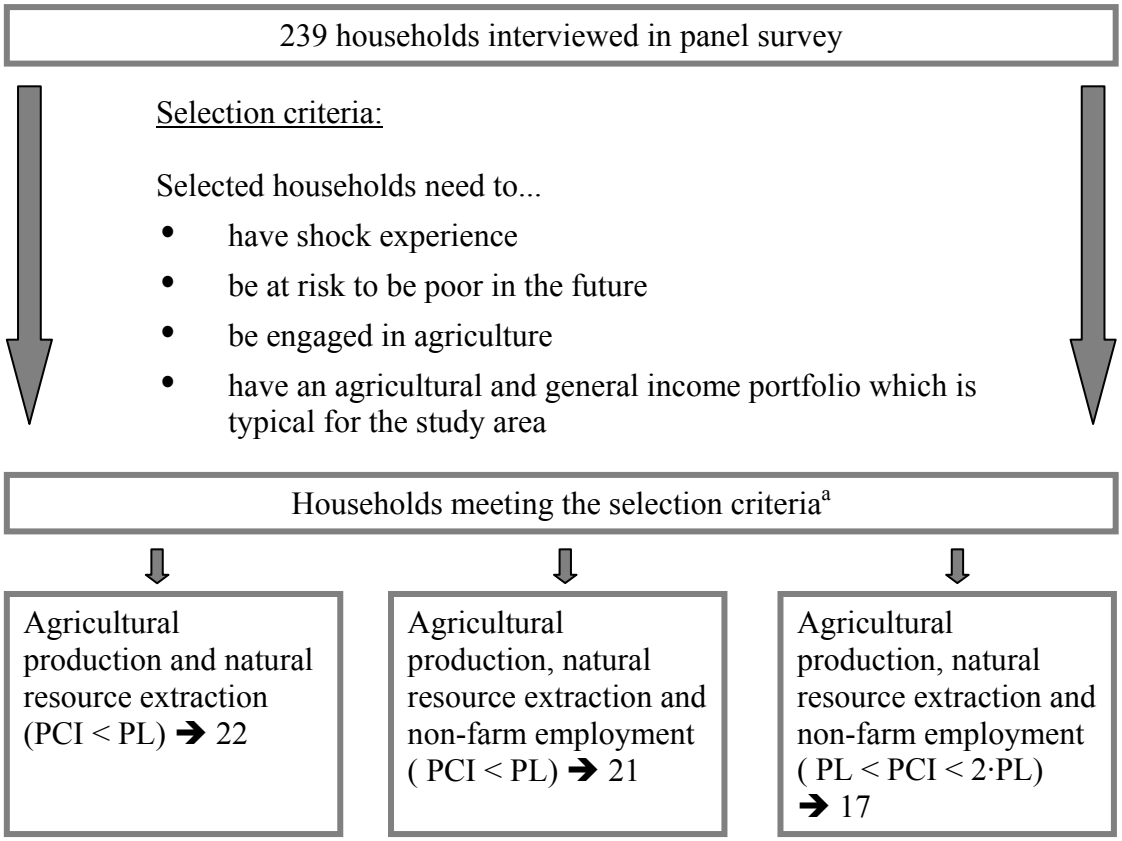

Figure 2.3: Overview of household selection procedure for the in-depth survey

Source: Based on Völker et al. (2008).

Note: [a] In order to accommodate organizational constraints, 60 households were randomly selected corresponding to three groups of typical farm households in the mountainous upland of Thua Thien Hue province. PL = Poverty line. PCI = Per capita income.

In the two-period panel base survey 239 households have been interviewed in the mountainous upland of Thua Thien Hue province. As first ad-hoc criterion for selecting the 60 households to be interviewed in the in-depth survey, the experience of shock events by households was used in order to get useful information about households' coping activities in the case of relevant economic shocks. Therefore, only households who had reported at least one shock with at least medium estimated severity in a reference period of 5 years were considered to be selected into the sub-sample. Shocks with low estimated severity are assumed to induce little coping-necessity, if there is any coping-necessity at all. Among all reported shocks in the 2007 base survey those with low estimated severity were the least prevalent ones.

Second, the average monthly income per nucleus household member was applied as a criterion. Households with an average monthly income per nucleus household member greater than 200% of the poverty line[4] for rural Vietnam were not considered eligible for the sub-sample for the in-depth case study. Since the overall topic of the study is vulnerability to poverty, only those households who are below the poverty line or relatively close above to the poverty line are of interest. It is assumed that such households face the risk of falling into poverty or, if already poor, even deeper into poverty in the advent of economic shocks.

Third, only households were selected to be interviewed in the in-depth survey which were engaged in own agricultural activities since the focus of the study is on farm households.

Fourth, households who received remittances from friends, relatives or absent household members which made up at least 60% of their total household income were not considered eligible for the sub-sample for the in-depth case study. Such households are atypical for Thua Thien Hue because data from the 2007 base survey indicate that the vast majority of households received considerably lower shares of remittances. They were excluded because it is assumed that interviewing households who receive a large fraction of their income from remittances are faced with little coping-necessity in the advent of agricultural production shocks.

Fifth, households with a share of land used mainly for cropping below 20% of total land were considered not eligible for the sub-sample for the in-depth case study in order to avoid having households in the sample who are strongly specialized in activities other than cropping such as livestock husbandry, fishing or logging. Descriptive analysis indicates that the average household in mountainous areas of Thua Thien Hue allocates the major share of total land to crops.

A descriptive analysis of those households which met these criteria revealed three household groups which were distinct with regards to their portfolio of income-generating activities and their income level. To account for differences across these

[4] Poverty line for rural Vietnam in 2007: 225200 VND per person per month. (Source: General Statistics Office of Vietnam)

three groups of households that could affect the intended quantitative modeling that is presented in chapter 4, detailed information from a similar number of households per group was collected. The eligible households were divided into the following 3 groups:

- households who were exclusively engaged in agriculture, fishing, hunting, collecting and/or logging;
- households who were additionally engaged in off-farm wage employment and/or non-farm self-employment and who had an income below the poverty line; and
- households who were additionally engaged in off-farm wage employment and/or non-farm self-employment and who had an income above the poverty line.

Initially, 20 households were randomly selected into each group. However, due to organizational reasons the final distribution of households into the group was slightly adjusted as can be seen in Figure 2.3.

2.4 Survey instrument

The base survey household questionnaire covered the demographic, economic and social situation of the household. It was designed based on standard modules of living standard measurement surveys and newly developed sections on shock experience and risk perception. The development was a joint task of the DFGFOR756 research unit. In particular, data on the following aspects were collected: (1) the composition of the household (including socio-demographic information on each member's social, educational, health and occupational status), (2) household dynamics, (3) the experience of shocks in the past and the perception of risk threatening the household in the future, (4) income-generating activities (including own agriculture, natural resource extraction, off-farm wage employment and non-farm self-employment), (5) financial activities, (6) household expenditures, and (7) land, housing and tangible assets. The base survey household questionnaire used in the first wave of data collection was used to collect retrospective information about the household's

economic activities in a 12-month period from May 2006 to April 2007, while in second wave of data collection the period from May 2007 to April 2008 was covered accordingly. In the shock section households were asked to report their experiences from a reference period of 5 years from January 2002 until April 2007 in the first wave and from May 2007 until April 2008 in the second wave. The risk section recorded the household's perceptions with regards to a future period of 5 years starting at the time of the interview.

The accompanying village head questionnaire captured the infrastructure and institutions of the survey villages. The surveyed aspects include: (1) the geographical position of the village, (2) means and costs of transportation for reaching important institutions and markets, (3) main economic activities, (4) social infrastructure (including irrigation, sanitation, etc.), and (5) community resources. The village head survey was conducted simultaneously with the first wave of the base household survey.

The in-depth survey questionnaire built on the results of the base household survey by using information about the household's economic activities and shock experience as a starting point for further, more detailed questions. With regards to the household's agricultural activities comprehensive data were collected on the use of production inputs and outputs. Moreover, a thorough review of further income-generating activities, including existing options and restrictions, was conducted. Finally, in-depth information about the effect of past shocks on the household's agricultural and non-agricultural activities as well as about the coping strategies which the household applied was collected. The in-depth survey questionnaire captured the household's economic activities from January 1st to December 31st 2008, with the shock section referring to shocks experienced between 2002 and 2008.[5]

[5] For the questionnaires of the base and in-depth survey see: http://www.vulnerability-asia.uni-hannover.de/.

2.5 Logistics and implementation of data collection

The in-depth survey in the mountainous upland of Thue Thien Hue province was implemented by the author who recruited three enumerators who were staff members at the Center for Rural Development in Central Vietnam, Hue University of Agriculture and Forestry (1 research associate and 2 MSc students). All enumerators had extensive prior survey experience and were recruited with the help of the International Center of the Hue University Learning Resource Center. The implementation of both waves of the in-depth survey was preceded by training workshops for the enumerators which were held in Hue City from 2nd-5th May 2008 and from 31st December 2008 to 1st January 2009. The first wave of the in-depth survey was conducted from 17th-26th May 2008 while the second wave place took place from 2nd-14th January 2009. The expert interviews with local forest and agriculture officers in the mountainous upland of Thua Thien Hue province were conducted simultaneously with the in-depth household survey in 2009.

2.6 Sample description

A first descriptive analysis of the collected survey data gives a general overview of socio-demographic characteristics and production activities of the targeted households. Table 2.1 presents socio-demographic characteristics of households in the three surveyed Vietnamese provinces based on data collected in the second wave of data collection. Results show that the average size of households is around 4 members with 1-2 children in all provinces. The heads of households living in Dak Lak are about 6-7 years younger than their counterparts in Ha Tinh and Thua Thien Hue which is possibly due to the high immigration rate in this province which attracts young families from other parts of the country.

The number of years household heads went to school varies between 5-8 years, which is at best hardly above primary school level and exhibits a relatively low general level of education. Dak Lak accounts for a relatively high share of ethnic minority households as compared to Ha Tinh and Thua Thien Hue. The average size of landholdings is around 1.2 hectare in Dak Lak and Thua Thien Hue while households

in Ha Tinh command over a considerably lower area of land of about 0.5 hectares. Most part of landholdings is used for agricultural purposes.

Total annual income is considerably higher in Dak Lak as compared to Ha Tinh and Thua Thien Hue, which is mainly due to the exceptionally high level of income from crop production in this province. In all provinces, crop production is among the main sources of income for rural households together with off-farm wage employment, non-farm self-employment and the consumption value of the owner-occupied dwelling. Livestock and aquaculture are more important in Dak Lak and Ha Tinh, while households living in Thua Thien Hue benefit disproportionately from the extraction of natural resources in the form of logging, collecting, hunting and fishing. Remittances are highest in Ha Tinh which is to be expected since it is the province with the lowest total income and households are in stronger need for external sources of income. Besides, the relative proximity to Hanoi might facilitate the temporary migration of household members.

Table 2.1: Household characteristics in Vietnam 2007/2008 (2nd base survey wave), by province

	Dak Lak N=736		**Ha Tinh** N=713		**Thua Thien Hue** N=697	
Household characteristics	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.
Household size	4.7	0.1	3.9	0.1	4.4	0.1
Number of children	1.9	0.1	1.3	0.1	1.7	0.1
Age of HH head (years)	45.3	0.5	52.4	0.6	51.5	0.7
Education of HH head (years)	6.3	0.3	8.4	0.2	5.5	0.2
Kinh ethnicity (%)	63.0	0.1	99.9	0.0	94.7	0.0
Total land (ha)	1.2	0.1	0.5	0.0	1.2	0.6
Land used for agriculture (ha)	1.1	0.1	0.4	0.0	0.9	0.6
Income components (1000 VND)						
Crop production	24970.0	2559.5	7682.3	1484.8	4746.1	653.8
Livestock and aquaculture	4175.8	531.4	5507.3	438.5	1912.4	522.0
Natural resourc extraction	-175.2	77.1	1839.7	508.0	12583.3	4910.9
Off-farm wage employment	4708.6	685.4	3822.5	355.8	4502.3	422.3
Non-farm self-employment	6042.3	967.1	3576.8	741.4	7049.0	998.1
Public transfers	1687.0	270.7	3076.6	367.6	1408.6	232.4
Remittances from HH members	1985.3	320.6	3009.9	654.2	834.3	111.5
Remittances from friends/relatives	595.6	182.5	1360.2	250.3	1318.0	244.3
House and land	6634.2	774.3	3845.2	304.4	4810.4	214.0
Depreciation of productive assets	-504.1	72.7	-289.4	68.8	-625.3	226.7
Loan interest payments	-1559.6	236.3	-919.6	422.3	-392.5	118.9
Indemnity payments	34.6	22.4	26.4	23.2	267.8	69.3
Total income	50641.3	3542.5	33855.5	2169.1	39190.4	5180.7

Source: DFGFOR756 base survey.

Note: Annual figures are shown for income components. Std. Err. = linearized standard error.

Table 2.2 dissects the information on socio-demographic characteristics by comparing the three groups of typical households surveyed in the in-depth case study. It shows that households are of a similar size across all household groups, while the number of economically active household members who have to provide for one dependent member differs slightly with households from group 1 facing the highest dependency ratio. The heads of households with a mixed activity portfolio (group 2 and 3) are about five years older than those of households from group 1, and have a slightly higher level of education as well. The higher education of mixed activity households could indicate that non-agricultural activities require higher education levels. Mixed households are also particular with regards to their ethnic origin, since household which belong to Vietnam's ethnic Kin majority can only be found in group 2 and 3, suggesting that those households generally have a better access to non-agricultural employment. Concerning the land endowment of households, it can be seen that a marked difference exists between total land owned and the area which is actually used

for agricultural production. Households in the study area usually possess some small forest areas and vacant land which is difficult to use for productive purposes. Households from group 1 use a smaller area of land for agriculture.

Average income from agriculture and natural resource extraction is relatively low for mixed activity households (group 2 and 3) as these households earn a considerable share of their total income from off-farm wage labor and non-farm self-employment. Although having been sampled as households not being engaged in off-farm wage labor and non-farm self-employment, households from group 1 also have some, even though little, income from these sources. Apparently some of these households that were not engaged in such activities in 2006/07, the time period about which the data was collected on which the sampling for the special survey was based, took-up additional occupation in 2007/08. In fact, as Table 2.3 indicates, households from this group were mainly engaged in construction and agricultural wage, popular casual employment types.

To the contrary, a higher share of households from group 2 and 3 were engaged in typically permanent, non-casual employment types such government jobs and own businesses. Households with members employed in the tourism and hospitality sector can only be found in group 3. Employment in that sector could generate high returns which may lift households above the poverty line. Overall, total average income is lowest for households in group 2 which receive considerably lower amounts of public transfer payments compared to households in the other two groups. By definition, total average income is highest for households in group 3.

Table 2.2: Household characteristics of typical households in the mountainous upland of Thua Thien Hue province 2007/2008, by typical household group

	Group 1 N=22		**Group 2** N=21		**Group 3** N=17	
Household characteristics	Mean	SD	Mean	SD	Mean	SD
Household size	4.5	1.6	4.2	1.8	4.8	1.6
Dependency ratio	0.9	0.6	0.8	0.7	0.7	0.5
Age of HH head (years)	41.7	15.0	44.5	13.7	44.7	13.8
Education of HH head (years)	4.1	2.8	5.0	4.3	5.7	5.0
Kinh ethnicity (%)	0.0		14.3		35.3	
Total land (ha)	1.5	1.7	1.7	1.3	1.1	1.4
Land used for agriculture (ha)	0.3	0.3	0.6	0.8	0.4	0.5
Income components (1000 VND)						
Crop production	4909.6	5107.7	2895.6	1980.8	3557.4	3886.6
Livestock and aquaculture	919.8	3048.1	653.2	2556.6	551.9	2618.8
Natural resourc extraction	723.6	1884.1	64.3	440.0	77.1	688.5
Off-farm wage employment	277.7	1064.0	3561.2	6403.0	4156.4	7256.1
Non-farm self-employment	12.0	56.4	1234.6	3348.5	0.0	0.0
Public transfers	4726.5	7240.6	776.2	1278.2	3144.3	8742.6
Remittances from HH members	18.2	85.3	0.0	0.0	70.6	291.0
Remittances from friends/relatives	90.9	426.4	680.0	2674.8	764.7	2905.4
House and land	1923.6	1298.1	2917.9	2565.6	2917.6	2745.0
Depreciation of productive assets	-6.5	6.2	-5.2	8.0	-39.8	119.3
Loan interest payments	-229.9	1021.7	-95.2	366.5	-37.4	87.3
Indemnity payments	0.0	0.0	0.0	0.0	11.8	48.5
Total income	13602.0	12663.4	12505.1	10830.3	15287.1	14458.7

Source: DFGFOR756 base survey and in-depth survey Thua Thien Hue province.

Note: Annual figures are shown for income components. SD = standard deviation.

Table 2.3 furthermore indicates the most important agricultural activities in which households of the three typical household groups engage. The agricultural production portfolio is similar across all three groups, with non-glutinous rice, acacia, corn, banana and cassava being the main crops cultivated by the majority of households in all groups, except of corn which is only cultivated by a minor share of households in group 3. The main livestock raised is beef cattle, buffalo, pig and chicken, although buffalos are only raised by very few households from group 2 and households from group 3 are more specialized in chicken production. The majority of all households extract fuelwood, with households from group 1 accounting for the largest share. Non-fuelwood timber and non-timber forest products are extracted by some households, with households from group 2 accounting for the largest share.

Table 2.3: Production characteristics of typical households in the mountainous upland of Thua Thien Hue province 2007/2008, by typical household group

	Group 1 N=22	**Group 2** N=21	**Group 3** N=17
Main own agricultural activities (%)			
Non-glutinous rice	77.3	76.2	82.4
Acacia	77.3	61.9	52.9
Corn	63.6	52.4	29.4
Banana	63.6	66.7	64.7
Cassava	59.1	76.2	70.6
Beef cattle	45.5	33.3	41.2
Buffalo	40.9	4.8	23.5
Pig (fattening)	31.8	33.3	47.1
Chicken	31.8	23.8	64.7
Natural resource extraction (%)			
Fuelwood extraction	95.5	81.0	88.2
Forest extraction (non-fuelwood)	13.6	28.6	11.8
Main other activities (%)			
Construction work	18.2	4.8	5.9
Agricultural wage work	13.6	9.5	11.8
Government job	0.0	9.5	5.9
Own business	4.6	9.5	5.9
Tourism and hospitality	0.0	0.0	11.8

Source: DFGFOR756 base survey and in-depth survey Thua Thien Hue province.

Note: Annual figures are shown for income components.

2.7 Summary

The data collection generated a comprehensive empirical basis for the analyses presented in chapters 3 to 5. Against the background of the research objectives of this work, data of special interest are those collected in the base survey questionnaire sections on agriculture, natural resources, shocks, risk and coping strategies. The collected data on households' shock experience, risk perception and coping behavior play a crucial role throughout the subsequent chapters, as they allow to assess the relationship between shock experience, risk perception, coping behavior and vulnerability to poverty at the household level. In chapter 3 the linkage between climate-related shock experience, risk perception and ex-ante coping behavior can be analyzed based on these data. Chapter 4 furthermore draws on the data on households' engagement in forest extraction in order to assess the relationship between different types of shocks on household labor supply to forest extraction.

In chapter 5, data on shock experience are used to derive a set of states of weather shock occurrence that households need to take into account when making decisions on how to set-up a risk-efficient activity portfolio. Chapter 5 also draws heavily on data collected in the agricultural section of the base survey. In addition, it exploits the data gathered in the in-depth survey in Thua Thien Hue province that allow for a more precise description of the technical production process of typical agricultural households in the research area, the specific constraints these households face and their experience of shocks. This information can then be used to set-up a suitable farm household model by means of mathematical programming.

The subsequent chapters also make use of data collected in other sections of the base survey, especially those on general socio-demographic household characteristics, income and wealth, off-farm wage labor, non-farm self-employment and village characteristics. Such additional data are required for both running econometric models in chapters 3 and 4 that need to control for a comprehensive set of factors which can affect the modeled outcome and setting-up the normative mathematical programming model in chapter 5 which needs to comprise all important characteristics of the modeled typical farm household.

Despite the relative comprehensiveness of the collected data some shortcomings remain that need to be taken into consideration when interpreting the presented results. With regards to the available information on shocks, it is important to understand that these are based on the interviewed households experience in reference period from 2002 to 2008. Shocks that happened before 2002 that may have an effect on the outcome of the econometric models in chapters 3 and 4 are not accounted for.

Furthermore, any information on risk used as parameters in the econometric models in chapters 3 and 4, and the normative mathematical programming in chapter 5 is based on the subjective perception of risk by the interviewed households. The subsequent chapters are therefore not intended to be objective risk models, but rather to explain individual household decision-making behavior which is based on this very subjective perception of risk. Finally, the collected data on agricultural production exclude some information, such as, for example, data on soil quality at the household- or even plot-

level. Considering such additional information may further improve the quality of the models presented in the work.

Chapter 3[6]

Forest extraction as a response to shocks

3.1 Introduction

Forests worldwide are known as a vital source of biodiversity and for providing important ecological services (Pearce 2001). Rising concerns about climate change and species loss have brought global benefits of forests in terms of climate regulation and wildlife habitat conservation to be the focus of public attention. As worries about the adverse effects of deforestation grow, there is an increased demand for effective protection of forests (Kramer and Mercer 1997). However, contrary to the global benefits of forest protection, the associated opportunity costs are mostly local and particularly affect people in developing countries who are living on the forest margin (Adams and McShane 1996, Norton-Griffiths and Southey 1995). For the local population tropical forests serve as a source of fuelwood, tropical hardwoods and non-timber forest products (NTFPs) for subsistence and sale, thus constituting an important source of household income (Babulo et al. 2009, Mamo et al. 2007). Beyond their regular use, forest products can provide rural households with a safety net when other sources of income fail. Forest extraction is presumed to be particularly important for households who are not able to use other risk-management and risk-coping strategies such as off-farm employment, formal credit and insurance, and agricultural diversification.

The general use of small-scale tropical forest extraction as a source of income has been the subject of various recent empirical studies, some of which focus on the identification of underlying factors. Poverty has been found to be a major driving

[6] This chapter is based on the article: Völker, M., & Waibel, H. (2010). Do rural households extract more forest products in times of crisis? Evidence from the mountainous uplands of Vietnam. Forest Policy and Economics 12 (6), 407-414.

force for households to extract forest products often beyond sustainable harvesting rates (Reddy and Chakaravarty 1999, Cavendish 2000, Schwarze et al. 2007). Little is known, however, how much of additional forest extraction takes place in times of crisis, i.e. when households experience negative covariate or idiosyncratic shocks. Covariate shocks (e.g. climatic events, price fluctuations) are those that can possibly affect all households in a community or area while idiosyncratic shocks (e.g. illness, unemployment) typically take place at the household level. Until to date, little quantitative information exists on the extent of forest extraction by rural households affected by shocks. Available studies mostly treated this issue in a qualitative manner (Dercon 2002, Wunder 2001, Falconer 1990, Paumgarten 2005, Huigen and Jens 2006, Angelsen and Wunder 2003, Godoy et al. 2000). Quantitative information so far is limited to a few studies in Latin America (e.g. Pattanayak and Sills 2001, Takasaki et al. 2004). Results indicate that the relative importance of forest extraction as a coping mechanism depends on the availability of alternative coping options. In her study McSweeney (2004) shows that the effects of idiosyncratic health shocks on forest extraction depend on the status of the affected household member.

This paper examines the role of forest extraction as response to adverse shocks among rural households in the mountainous upland of the Vietnamese provinces Dak Lak, Ha Tinh and Thua Thien Hue. The study areas belong to the sparsely populated and predominantly rural mountainous parts of Vietnam's Central Highlands and North Central Coast region where a large share of the population is made up by ethnic minorities and from where poverty rates of more than 40% are reported for the vast majority of communes (Epprecht and Robinson 2007, Rambo and Jamieson 2003). According to Rutter (2001), forest products play an important role in the livelihoods of local households in Vietnam, both for their regular needs and as a source of additional income in order to mitigate the adverse effects of shocks. However, unsustainable extraction of fuelwood, rattan and bamboo already threatens the integrity of forest areas in Vietnam.

The objective of this paper is to clarify how different types of shocks faced by rural households in the mountainous areas of three provinces in Vietnam affect the engagement of these households in forest extraction. The following four questions are investigated:

1. What are the extent and the pattern of forest extraction in the study area?
2. What types of adverse shocks affect rural households?
3. How do households cope with adverse shocks?
4. How do covariate weather shocks and idiosyncratic health shocks change the extent of a household's labor allocation to forest extraction?

The paper is organized as follows: the next section provides an explanation of the household model which has been developed as the theoretical basis for the empirical analysis. Results of a descriptive analysis of data are presented in section 3.3. In section 3.4 the methodology used for empirically testing the relationship between shocks and forest extraction is explained. Section 3.5 presents the results of an econometric analysis, and the last section concludes.

3.2 Theoretical model

The theoretical framework underlying the empirical analysis of forest extraction as coping mechanism is based on "new home economics" theory (Becker 1965). Applied to developing countries (e.g. Ellis 1993), the emphasis of the "new home economics" theory, is on the household's time allocation assuming that labor is the major factor of production. Households in the study areas fit into this pattern. Only households not engaged in off-farm wage employment were included. Figures 3.1 and 3.2 give a graphical presentation of the basic home economics household model showing household output in relation to available time. Time, depicted on the horizontal axis of the graphs, is divided into labor for agriculture ($0T_A$), forest extraction (T_AT_F) and leisure (T_FT).The time constraint is determined by the total number of person days available for agricultural production, forest extraction and leisure. The graphs depict two scenarios of household labor allocation comparing a situation with and without shocks. Figure 3.1 represents a weather shock scenario with effects on agricultural

output while Figure 3.2 represents a scenario where a family member is falling sick with corresponding effects on labor capacity.

To explore in more details the effects of a covariate weather shock on the time allocation of the household Figure 3.1 is used as a framework. Weather shocks such as heavy rain or flooding lower agricultural output. A key assumption of the model is that weather risk associated with agricultural production is uncorrelated with forest extraction risk (as also suggested by McSweeney 2004) and that even for weather risks like storms the effect on forests is comparatively small (unless it is a extremely strong typhoon) due to the diversity of products which can be extracted. Therefore the effect of a weather shock is modeled solely by its effect on the household's agricultural production function while the household's average returns to forest extraction (ARF) remain unaffected. Weather shocks reduce the household's agricultural production output in the form of crop yields and livestock products, thereby decreasing labor productivity. The shape of the agricultural production function changes (APF to APF') reflects a relatively poor input-output response as compared to the baseline scenario. Using the same amount of time for farm work, the household produces less output because the marginal productivity of time allocated to agricultural production has decreased. This results in a new equilibrium of the household in agricultural production (point A' instead of point A), which shows that the household allocates less time to agriculture ($0T_A'$ instead of $0T_A$) and accordingly more time to forest extraction ($T_A'T_F$ instead of T_AT_F). The time allocated to leisure remains the same as neither the indifference curve nor the average returns to forest extraction are assumed to be altered by the weather shock. Consequences of *ex-ante* weather risk can be modeled accordingly by assuming that households make time allocation decisions based on expected states of nature, meaning that pessimistic households face a relatively poor subjective *ex-ante* input-output response curve regarding agricultural production as compared to more optimistic households.

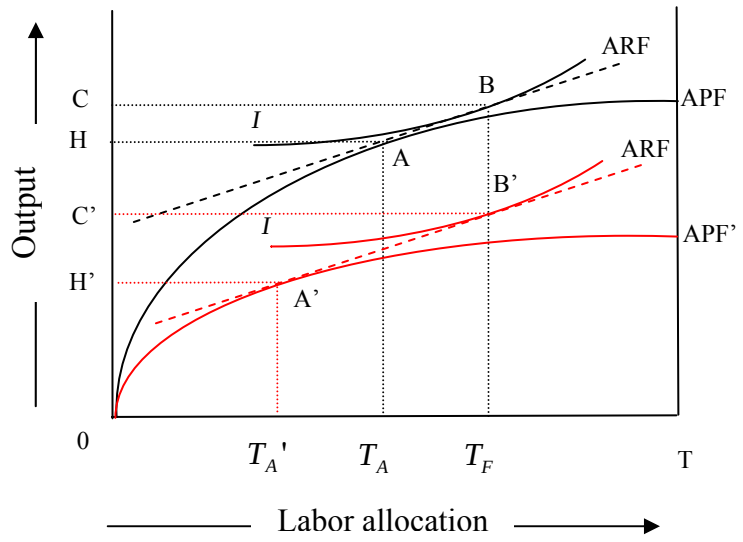

Figure 3.1: The home production model under a weather shock scenario
Source: Adapted after Ellis (1993).

Figure 3.2 analyzes the effects of a health shock. Health shocks relate to active household members who become ill. Illnesses of household members are assumed to have two effects. On the one hand, they reduce the total household time capacity if the affected household member is not able to carry out the normal amount of work. This is reflected by a shortening of the horizontal axis to the left. On the other hand, the household faces additional needs for health care which increases the family's preferences for consumption goods instead of leisure. This is reflected by the shape and position of the consumption-leisure indifference curve which has a shallower slope than in the baseline scenario (*I'* instead of *I*). Provided the household is able to reallocate leisure time to forest extraction, a new equilibrium in the consumption of goods emerges (point B'), which shows that the household allocates less time to leisure ($T_F'T'$ instead of T_FT) and accordingly more time to forest extraction (T_AT_F' instead of T_AT_F). The optimal production level of consumption goods (point A) remains the same as both the agricultural production function and the average returns to forest extraction are assumed to remain unaffected by the health shock. Again, consequences of respective *ex-ante* risk can be modeled accordingly. Households who have pessimistic expectations about future health shocks might face a shallower

income-leisure indifference curve as they may want to accumulate savings for future times of hardship.

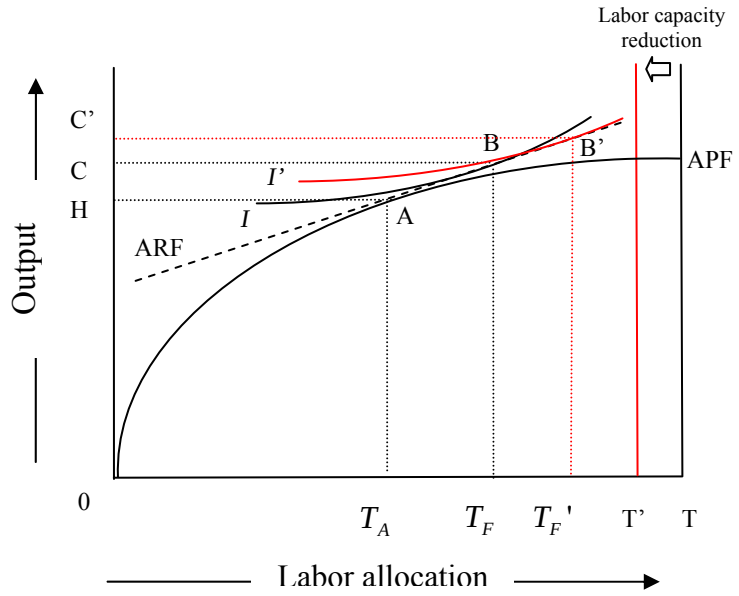

Figure 3.2: The home production model under a health shock scenario
Source: Adapted after Ellis (1993).

The theoretical model suggests the hypothesis that a covariate weather shock and an idiosyncratic health shock, as well as decision-makers' future expectations of such risks will make the household allocate more labor to forest extraction.

3.3 Descriptive statistics

In the following the results of a descriptive analysis of survey data are presented to illustrate the livelihood conditions that exist in the study area. Selected indicators which give an impression of the poverty status of households in the study areas and their engagement in forest extraction are shown. Furthermore, the major shocks which affect local households and the coping activities taken-up to deal with their adverse effects are identified.

The quantitative data used in this study form a subset of the DFGFOR756 base survey dataset. The study areas comprise the mountainous upland of Dak Lak, Ha Tinh and Thua Thien Hue provinces. The subset of data includes 889 households from 45 communes in the mountainous upland districts Buon Don, Cu M'gar, Ea Hleo, Krong A Na, Krong Buk, Krong Nang, Krong Pac (all belonging to Dak Lak), Huong Khe, Huong Son, Vu Quang (all belonging to Ha Tinh), A Luoi and Nam Dong (both belonging to Thua Thien Hue), covering two villages per commune. In addition to the DFGFOR756 data, secondary 90 meter digital elevation data were used in this analysis which was obtained from the Consultative Group on International Agricultural Research Consortium for Spatial Information (Jarvis et al. 2009).

In order to obtain supplementary background information about forest conditions, patterns of forest extraction and forest access regulations in the mountainous upland of Thua Thien Hue, interviews with three experts in that field were carried out (Huang 2009, Tran Dinh, H. 2009, Tran Dinh, T. 2009). The experts are officers of the local forest management departments in A Luoi and Nam Dong districts, respectively, and a village leader from Nam Dong district who were selected on the basis of their locally recognized competence in the field of forestry. The selection of the experts was performed based on the advice of the Centre for Rural Development in Central Vietnam, Hue University of Agriculture and Forestry.

Poverty and vulnerability indicators

The average per capita consumption as well as the poverty incidence in the mountainous upland of Dak Lak, Ha Tinh and Thua Thien Hue in 2006/2007 is shown in Table 3.1.

Table 3.1: Per capita consumption and poverty incidence in the mountainous upland of Dak Lak, Ha Tinh and Thua Thien Hue 2006/2007

	Consumption		**Poverty head count**	**Poverty gap**	**n**
	Mean	*Std. Err.*	*(%)*	*(1000 VND)*	
Total	518.9	26.4	22.2	13.3	889
Dak Lak	568.8	35.2	14.3	7.9	491
Ha Tinh	399.4	29.9	21.4	11.6	159
Thua Thien Hue	337.3	28.7	38.9	25.4	239

Source: DFGFOR756 base survey.
Note: Consumption = monthly per capita consumption in 1000 VND. VND = Vietnamese Dong. 100,000 VND = 4.74 Euro (April 30th 2007). Poverty line for rural Vietnam 2007 = 225.2 thousand VND per person per month (GSO 2006). Std. Err. = linearized standard error. The poverty head count measures the share of households below the poverty line. The poverty gap measures the average shortfall of consumption from the poverty line.

Results indicate that a substantial share of the population in the mountainous upland is poor and considerably below the national poverty rate. On the other hand there is large heterogeneity of poverty across the mountainous upland of the three provinces as shown in Table 3.1. Thua Thien Hue accounts for a relatively low mean per capita consumption and a high incidence of poverty while Dak Lak appears to be comparatively well off.

Forest extraction

Households in the study areas are engaged in the extraction of different forest products (Table 3.2). According to the expert interviews (Huang 2009, Tran Dinh, H. 2009, Tran Dinh, T. 2009) over 80% of land in the mountainous upland of Thua Thien Hue is covered by forest. This forest is divided in three parts: protection forest, special use forest and production forest with roughly equal shares. That categorization applies to the whole of Vietnam (Clement and Amezaga 2009), though the distribution of forest land across these categories differs between provinces. Different degrees of

access restriction exist. In protection forest no extraction is allowed, while in special use forest access is limited and only production forest is for permanent use but some rules for extraction exist. Forest extraction is referred to as the collecting, logging and hunting of wild forest products. The main activity is the extraction of fuelwood which is mainly used for own subsistence purposes such as cooking and heating. Fuelwood is mostly extracted in secondary forests in proximity of the village. Alternatively fuelwood is extracted in acacia and rubber tree plantations, in the household's own home garden or as a by-product of slash-and-burn activities.

Other forest products are extracted by some villagers and these comprise timber types other than fuelwood as well as NTFPs such as honey, rattan and wild animals. High quality timber is logged by small groups of villagers who stay in the often remote old growth forest areas in order to jointly engage in the extraction tasks. The wood is bought by traders from other provinces at high prices. The range of collected NTFPs is broad. Shops which buy NTFPs can be found in every village. Results of a descriptive analysis indicate that most households who collect NTFPs sell at least part of them, thus generating an additional source of cash income (Table 3.2). On average, households go to the forest once per month to extract forest products. According to the expert interviews the forest labor supply follows a seasonal pattern. Households usually extract forest products during the rainy season between September and December. During that time households lack income from farming activities. They extract forest products in order to meet subsistence needs, and to generate income for buying seeds and other agricultural production inputs for the next cropping season.

Table 3.2: Forest extraction activities of rural households in the mountainous upland of Dak Lak, Ha Tinh and Thua Thien Hue 2007/2008 (*n*=889)

	Households involved	**Extraction days**		**Selling households**
	%	*Mean*	*Std. Err.*	*%*
Total	38.4	12.0	1.6	2.2
Fuelwood	37.4	10.4	1.1	1.5
NTFPs	1.1	1.0	0.8	1.1
Non-fuelwood timber	0.3	0.3	0.3	0.3

Source: DFGFOR756 base survey.
Note: Std. Err. = linearized standard error.

According to information provided by the interviewed experts (Huang 2009, Tran Dinh, H. 2009, Tran Dinh, T. 2009) access to forests in the study areas is increasingly governed by community-level access control programs which are being set up in order to tackle the problem of illegal extraction or unsustainable management of forest resources that occurred due to the lack of access control from the government side. In A Luoi district in Thua Thien Hue, 6 communes have primary old-growth forest with a high level of biodiversity. Access in 5 of these communes is governed by community groups, consisting of 10 households each, which jointly control and manage forest areas for which they get permission from the local administration. In one commune the access control of forest resources has been allocated directly to the households, with 15 households who control 15 hectares each. In Nam Dong district in Thua Thien Hue each commune is permitted to extract 30 cubic meters of forest goods per annum. Commune leaders decide which households are allowed to participate in the extraction benefiting those households who are poor or who suffered from shock events.

Shock incidence and coping activities

Households in the mountainous upland of Dak Lak, Ha Tinh and Thua Thien Hue were affected by different types of idiosyncratic and covariate shocks during the 6-year reference period (1/2002 – 4/2008) covered by the survey. These shocks had different consequences on the households. Income losses occurred when households could not generate as much income as they would normally have created, for instance, when crop yields were damaged as a result of bad weather. Asset losses were a further result of shocks, especially of weather shocks such as storms, which resulted in the loss of physical assets such as agricultural land and buildings or when a household was forced to sell assets. Idiosyncratic shocks mainly comprised health shocks, such as illness and death of household members, but also household damage and theft. Covariate shocks predominantly included weather shocks like storm and flooding of agricultural land, as well as crop pests and livestock disease. Economic shocks, such as input and output price fluctuations played a minor role. Most reported shocks were

of high perceived severity[7]. Results indicate that about 84% of all households were affected by income losses due to shocks, with weather-related shocks being the most severe shock types in terms of asset loss. The majority of reported shocks which occurred before 4/2007 still affected households at the time of the survey as the households had not fully recovered from them.

As a response to the shocks experienced, households applied a range of different coping strategies (Table 3.3). Many households substituted crops, mostly on agricultural production plots which were damaged by natural calamities. Some households diversified their agricultural portfolio, thus changing to a different composition of agricultural activities. Alternative coping mechanisms were the sale of assets and the use of savings. A further choice observed was the enhancement of household liquidity and tangible asset endowment by borrowing and receiving cash and goods from different sources. The coping strategy of most interest in the context of natural resource extraction was taking-up of additional activities. While in the questionnaire "additional forest extraction" was not used as code due to the political sensitivity of this issue it is reasonable to assume that the answer "taking up additional activities" provides evidence for forest extraction as little other alternatives exist. This conclusion is supported by the findings of an in-depth case study of a sub-sample of 60 households from the DFGFOR756 sample in the mountainous upland of Thua Thien Hue which show that households often extract more forest products as response to shocks (Völker et al. 2008).

[7] The severity of shocks was subjectively elicited based on households' perceptions. Households were asked to assess the severity with which each shock affected them based on an ordinal scale from 1 (no impact) to 4 (high severity).

Table 3.3: Strategies to cope with shocks of rural households in the mountainous upland of Dak Lak, Ha Tinh and Thua Thien Hue 2007/2008 (*n*=889)

	% of households
Taking up of additional occupation	14.4
Diversification of agricultural portfolio	1.4
Substitution of crops	6.6
Sale of assets	5.8
Use of savings	3.3
Borrowing from	
Informal money lender	4.3
VBSP/VBARD	6.4
Receiving monetary/non-monetary help from	
Government	3.4
Non-governmental organizations	3.5
Friends, neighbours, relatives	3.2

Source: DFGFOR756 base survey.
Note: VBSP = Vietnam Bank for Social Policies.
VBARD = Vietnam Bank for Agriculture and Rural Development.

3.4 Empirical model

In order to empirically test the research hypothesis that weather and health shocks are correlated with a household's labor supply to forest extraction, an econometrical analysis is applied which aims at the identification of factors which determine a household's decision to engage in the extraction of forest products. Therefore, the probability of engaging in the extraction of forest products is estimated using a standard probit model,

$$\Pr ob(extract_i = 1) = F(\delta S_i + \psi R_i + \phi X_i + \varphi Y_v + \gamma P_p) \quad (6)$$

where I indexes household, $extract_i$ is a binary variable which indicates whether a household was engaged in forest extraction at least once in a 12- month reference period (May, 1st 2007 – April, 30th 2008), S_i is a vector of shock measures, and R_i is a measure of perceived risk regarding future shocks. Risk is measured as the number of shocks which a household expects to happen in a reference period of 5 years starting at the date of the interview, weighted by the expected severity of the events. X_i is a vector of socio-demographic household characteristics which are expected to affect the decision of a household to engage in forest activities both in the absence and

advent of a shock event (Kaimowitz and Angelsen 1998, Pattanayak and Sills 2001, McSweeney 2004, Takasaki et al. 2004). These household characteristics include ethnicity of the household head, number of household members, financial assets value, tangible assets value, and education of household head. The index v refers to village, and Y_v is the travel time to the nearest market from a village. Finally, P_p is a vector of dummy variables to capture the effect of the provinces. The variables used in the regression analyses are specified in Table 3.4. Following the theoretical model described above, only households that were not engaged in formal, non-casual off-farm wage employment or non-farm self-employment were considered in the analysis.[8] Four variants of the model are estimated with different specifications of the shock variables. Model 1 includes a variable which measures the total number of shocks that affected a household in a 6-year reference period between January, 1st 2002 and April, 30th 2008[9]. In model 2 that measure is disaggregated by the perceived severity of the shocks as less severe events are expected to cause relatively little coping-necessity. In order to explicitly estimate the effect of the most prevalent shocks and test the hypothesis which the theoretical model suggests, model 3 controls for the respective number of weather shocks of high and medium severity, and includes a health shock variable which measures the total number of months during which household members could not pursue their main occupation due to illness in a 12-months reference period between May, 1st 2007 and April, 30th 2008 (disaggregated by the economic role of the affected household members within the household). Thus, differences in the households' response to weather and health shocks in terms of labor allocation to forest extraction can be identified.

[8] Formal and non-casual employments were defined as employments with a duration of more than 2 months.

[9] The 6-year reference period was chosen as it was assumed that respondents would still have sufficient memory about those events.

Table 3.4: Variables in the regression models (*n*=277)

	Mean	Std. Err.
Dependent variable		
Forest extraction (1=yes)	0.57	
Explanatory variables		
Ethnicity (1=Kinh)	0.47	
No. of household members	4.64	0.12
Financial assets value (1000 VND)	4145.74	1052.80
Tangible assets value (1000 VND)	36251.84	4406.43
Household head education (years of schooling)	5.66	0.23
Time to market (minutes)	48.36	2.28
Ha Tinh dummy (1=Ha Tinh)	0.17	
Dak Lak dummy (1=Dak Lak)	0.40	
No. of shocks 02-08	3.43	0.10
No. of shocks 02-08 high/medium severity	3.34	0.10
No. of shocks 02-08 low severity	0.07	0.02
Illness weeks of active hh members 07/08	3.15	0.47
Illness weeks of dependent hh members 07/08	2.33	0.58
No. of weather shocks 02-08 high/medium severity	1.58	0.06
Risk score	62.81	35.45
Exogenous instrument for weather shocks		
Elevation level (meter)	509.26	15.88

Source: DFGFOR756 base survey and Jarvis et al. (2009) (for exogenous instrument for weather shocks).
Note: Std. Err. = linearized standard error. Only households that were not engaged in formal, non-casual off-farm wage employment or non-farm self-employment were considered in the analysis. VND = Vietnamese Dong.

Model 4 employs an instrumental variable method in order to overcome the problems associated with a possible omitted variable bias (i.e. bias in a coefficient because the respective variable is correlated with the error term of the regression equation). The standard probit estimate of the effect of weather shocks on forest labor supply could suffer from endogeneity bias as forest extraction in previous periods may determine both the frequency of weather shocks (because extraction deteriorates the erosion protection function of forests) and the probability of engaging in forest extraction. Therefore, an instrumental variable approach is applied. The first stage regression which estimates the number of weather shocks takes the form:

$$S_i^w = \lambda S_i^h + \psi R_i + \phi X_i + \varphi Y_v + \gamma P_p + \sigma I_c \quad (7)$$

where S_i^w measures the number of weather shocks that affected a household in the 6-year reference period, and S_i^h is a vector of health shock variables which measure the

total number of weeks during which household members could not pursue their main occupation due to illness in the 12-year reference period. X_i, R_i, Y_v and P_p are specified as in the standard probit model. As instrument I_c the average elevation levels of the sample communes are used (Jarvis et al. 2009). This provides exogenous variation in weather shock frequency to identify effects on forest labor supply. The second stage regression which estimates the probability that a household was engaged in forest extraction in the 12-months reference period takes the following form:

$$\Pr ob(extract_i = 1) = F(\nu S_i^w + \lambda S_i^h + \psi R_i + \phi X_i + \varphi Y_v + \gamma P_p) \quad (8)$$

This equation is the standard probit model, except that the instrumented weather shock measure, derived in the first stage regression, is introduced.

3.5 Results

Results of the probit models are shown in Table 3.5. The Wald test for joint significance of covariates is satisfied by all models. The statistical quality of the regression estimates varies, with standard probit model 3 showing the best goodness of fit. Standard probit model 3 shows that severe weather shocks are significantly and positively correlated with a household's labor allocation to forest extraction. For every severe weather shock by which a household was affected, the chance that the household extracted forest products at least once increased by 7.4%. This implies that the decision of a household to engage in forest extraction depended on the number of severe weather shocks which have affected the household in the past as hypothesized in our theoretical model.

Table 3.5: Probit regressions of household participation in forest extraction against socio-economic characteristics (*n*=277)

	Probit (1)		**Probit (2)**		**Probit (3)**		**IV-Probit**	
	Coef.	dF/dx	Coef.	dF/dx	Coef.	dF/dx	Coef.	dF/dx
Household characteristics:								
Ethnicity dummy	- 0.351	- 0.129	- 0.348	- 0.128	- 0.363	- 0.137	- 0.107	- 0.042
Household size	0.084	0.031	0.083	0.031	0.072	0.028	- 0.007	- 0.003
Financial assets value	$-6\cdot10^{-6}$	$-2\cdot10^{-6}$	$-6\cdot10^{-6}$	$-2\cdot10^{-6}$	$-5\cdot10^{-6}$	$-2\cdot10^{-6}$	$-3\cdot10^{-6}$	$-1\cdot10^{-6}$
Tangible assets value	$-4\cdot10^{-6}$ **	$-2\cdot10^{-6}$	$-5\cdot10^{-6}$ **	$-2\cdot10^{-6}$	$-4\cdot10^{-6}$ **	$-2\cdot10^{-6}$	$-3\cdot10^{-6}$ **	$-1\cdot10^{-6}$
Household head education	- 0.047 *	- 0.018	- 0.048 *	- 0.018	- 0.046 *	- 0.018	- 0.032	- 0.012
Village/province characteristics:								
Time to market	0.004	0.001	0.003	0.001	0.004	0.001	$4\cdot10^{-5}$	$2\cdot10^{-5}$
Ha Tinh dummy	- 0.337	- 0.129	- 0.357	- 0.137	- 0.257	- 0.100	- 0.403	- 0.159
Dak Lak dummy	- 0.821 **	- 0.289	- 0.839 **	- 0.296	- 0.737 *	- 0.270	- 0.227	- 0.088
Lost main occupation weeks:								
Active members					0.028 *	0.011	0.003	0.001
Dependent members					- 0.003	- 0.001	0.007	0.003
Number of shocks:								
All	0.021	0.008						
High/medium severity			0.029	0.011				
Low severity			- 0.078	- 0.029				
Weather high/medium severity					0.193 *	0.074	0.872 ***	0.341
Risk:								
Risk score	0.011 *	0.004	0.011	0.004	0.009	0.009	0.007	0.003
Constant	0.293		0.310		0.029		- 0.894	
P > chi² (Wald - joint significance)	0.000		0.000		0.000		0.000	
Pseudo R^2	0.188		0.189		0.209			
P > chi² (Wald - exogeneity)							0.152	

Source: DFGFOR756 and Jarvis et al. (2009) (for exogenous instrument for weather shocks). Note: *P<0.1, **P<0.05, ***P<0.01. dF/dx indicates the marginal effect of a one-unit change in the explanatory variable on the probability to engage in forest extraction. Only households that were not engaged in formal, non-casual off-farm wage employment or non-farm self-employment were considered in the analysis.

Results also indicate that health shocks in the present period had a significant positive effect on a household's decision to extract if economically active household members were affected by illness. The magnitude of this effect was smaller than in the case of severe weather shocks since for every week that economically active household members could not pursue their main occupation due to illness, the probability that the household engaged in forest extraction rose by only 1.1%. However, given that finding, it is indicated that the likelihood to extract forest products increased to a more substantial extent if the household was affected by longer-term illnesses of economically active household members. No significant correlation could be identified between health shocks which affected dependent household members, such as elderly persons, housewives or school children, and the probability that the household was engaged in forest extraction. These findings clearly indicate that whether or not a household turns to forest extraction depends on who in the households suffers from illness.

The value of a household's tangible assets at the beginning of the current period had a significantly negative effect on forest labor supply, suggesting that the depletion of tangible assets serves as an alternative coping-mechanism which households exploit in the event of shocks. This finding is in line with prior evidence such as that of Dercon (2002) who shows that households build up assets in good years, which they deplete in bad years in order to insure themselves. However, the size of the effect of assets value is small, indicating that only households with tangible assets of a substantially higher value were considerably less likely to be engaged in forest extraction. In fact, the possibility to deplete tangible assets of relatively low value in times of crisis can be limited if a household is in need of cash while possessing assets which are difficult to sell on local markets. The value of a household's financial assets is not significantly correlated with forest labor supply. The reason for this unexpected result could be that the role of cash savings as a resource for coping with shocks can be constrained by the generally low value of households' financial assets in remote rural areas in Vietnam. The size of the effect of assets value in both cases is small.

Households with household heads with more years of formal education allocated significantly less labor to forest extraction. Every additional year of education decreased the probability that the household exploited forest products by 1.8%.

However, the magnitude of the effect of education would be much greater if, for example, an additional 5 years of education would be considered. Better education can be a requirement for intelligent farm management, thus widening a household's scope of coping strategies other than forest extraction. Household size had a positive effect on forest extraction, which was expected because larger households require more fuelwood for cooking and heating. Households with a relatively large number of members could also be driven into the forest when their land endowment is limited. However, the respective coefficient was not found to be significant.

Location factors were a key determinant of household labor allocation to forest resource extraction. Households living in Dak Lak were significantly less likely to engage in forest extraction. Living in Dak Lak decreased the chance that a household extracted forest resources by 27%, which is the strongest effect in magnitude which was found by the model. Structural differences such as independent forest management departments with different forest access control approaches exist between provinces which can cause differences in forest extraction in response to shocks. The allocation of forest land to households and communes, for instance, as observed in the mountainous upland of Thua Thien Hue and politically intended by the Vietnamese government, has not been implemented consistently across Vietnam due to the relative freedom which is provided to provincial governments to put into operation national policies within their administrative borders (Clement and Amezaga 2009). Households in villages closer to market places might be more likely to allocate labor to the extraction of forest goods, because forest products can easily be sold to forest products buying shops in rural villages. Hence households living close to a market may have greater incentives to exploit that income generation option. However, the outcome of the model shows that the respective coefficient is not significant.

Ethnicity was found to have no significant effect on forest extraction either, meaning that households who belong to the Kinh majority were not more or less likely to extract forest products than households who belong to one of the numerous ethnic minorities. *Ex-ante* risk perception is positively, though not significantly, correlated with forest extraction. Thus, households which expected a larger number of relatively severe shocks to happen in a future period of 5 years were not more likely to engage

in the extraction of forest products. Households may not use forest extraction as an *ex-ante* risk management strategy because forest products are available year-round. Hence forest products can be extracted at any time as an *ex-post* shock coping strategy and households do not need to store forest goods in advance to prepare for times of hardship. Results of standard probit models 1 and 2 are largely consistent with model 3 while furthermore showing that shocks in general and severe shocks are not significantly correlated with a household's labor allocation to forest extraction, which highlights the importance of distinguishing between different shock types. Testing the effect of shocks on labor supply to forest extraction in an aggregated manner neglects that different shock types require distinct coping strategies. The outcome of the instrumental variable probit model[10] confirms the finding that severe weather shocks drove households into allocating more labor to forest extraction while the coefficients on health shocks are not significant anymore in this specification. However, the Wald test of exogeneity of the instrumented variables could not reject the null hypothesis of exogeneity. Hence, the instrumental variable method is not superior to the standard probit model.

3.6 Summary, conclusions and recommendations

Overall the empirical findings from the mountainous upland of Dak Lak, Ha Tinh and Thua Thien Hue support the results of previous studies which have been conducted in different geographical settings and which suggest that the incidence of shocks is a determinant of forest extraction (Pattanayak and Sills 2001, McSweeney 2004, Takasaki et al. 2004). Regarding the extent and the pattern of forest extraction (objective 1) it can be shown that a considerable share of households in the study areas is engaged in forest extraction, with the collecting and logging of fuelwood for subsistence purposes being the most important activity, and the sale of fuelwood, non-fuelwood timber and NTFPs playing a minor role. Referring to the different types of shocks (objective 2), particularly weather shocks and human health shocks, caused households to apply a range of coping strategies among which forest extraction ranks high (objective 3).

[10] Table 5 shows results of the second-stage probit regression. Results of the first-stage OLS regression, which indicate that the selected instrument is significantly correlated with the number of weather shocks of high/medium severity, are presented in Appendix A.

The results of this study corroborate the research hypothesis that both health shocks experienced by economically active household members and covariate weather shocks drive households into allocating labour to the extraction of forest products as suggested by the new home economics-type model described in the theoretical section (objective 4). Because weather shocks particularly affect agriculture such events prompt households to intensify their engagement in forest extraction. In concluding, the findings of this study suggest that forests are an important source of income not only for poor households as suggested by other studies (Schwarze et al. 2007, Shackleton et al. 2007).

The role of forest as "shock absorber" needs to be considered in evaluating policy options regarding both socio-economic development and the protection of natural resources. There is a need for suitable government interventions that can help to achieve a balance which on the one hand leaves vulnerable parts of the population living on the forest margin the opportunity to generate income from forest extraction in times of hardship, and on the other hand enables a sustainable management of natural resources. Forest protection policies which are too restrictive may compromise the shock-coping capacity of vulnerable households. The outline of recently introduced forest access control programs in the study areas indicates a growing awareness among local policy makers who aim to protect endangered forest resources while allowing for a constricted extraction by at least part of the vulnerable population.

Changes of the land law which have been enacted in 2004 allow for the allocation of land (including forest) to communities, hence facilitating community forestry as a means to provide access to forest products to vulnerable households while at the same time aiming for a sustainable management of the resource (Sunderlin and Ba 2005). While the ongoing unsustainable degradation of forest lands in Vietnam suggests that simple prohibitions of extraction have been proven ineffective, such recently introduced forest access control schemes, which delegate both the extraction and protection of forest resources directly to the households, appear to be more promising. These approaches should be further strengthened in Vietnam as there is preliminary evidence they can lead to an improved management of natural resources (Nguyen Hai

Nam 2002). More detailed insights about the impact of such access control programs on the households' shock-coping capacity, however, require further studies.

Chapter 4[11]

Impact of price shocks on typical farm households

4.1 Introduction

Farm households in developing countries face considerable risk in their agricultural production due to the effects of a wide range of shocks (Dercon 2002). The 2008 price crisis in the world markets for agricultural commodities, fuel and chemical fertilizer came as such a shock to both producers and consumers, particularly in Asia, Sub-Saharan Africa and Central America (von Braun et al. 2008). In principle, a hike in food prices offers both opportunities and risks to poor households in developing countries depending on which livelihood group they belong to. On the one hand, it is argued that households which buy more food than they sell (net buyers) are likely to suffer from high food prices (Brinkmann et al. 2010). On the other hand, it is argued by some analysts that net-selling food producers could gain from high international prices of food (von Braun 2008). However substantial differences in the transmission of food prices across and within countries have been reported (Dawe 2008, Cudjoe et al. 2008). Price effects might not be fully translated to equivalent changes in farm gate prices in rural regions as these are more isolated from international markets due to high transport costs. Moreover, rising costs of agricultural production, particularly of fertilizer, may offset gains from rising food prices (ALNAP 2008).

In addition to price shocks, broad economic downturns such as the 1997 Asian Economic Crisis or the recent global financial crisis, can affect non-agricultural

[11] This chapter is a modified version of Völker, M., S. Tongruksawattana, H. Waibel and E. Schmidt (forthcoming). Impact of food price shocks on vulnerability to poverty: a mathematical programming Approach. In: Klasen, S. & Waibel, H. (Eds.), Vulnerability to poverty: theory, measurement, and determinants. Palgrave. The book chapter extends the analysis presented in this thesis to additional types of typical households both in Vietnam and Thailand. A modified version of the book chapter will be submitted to *Agricultural Systems*.

activities of farm households when household members who are engaged in off-farm wage labor or non-farm self-employment are forced to migrate back to their rural place of origin (ADB 2009b) and to reduce the amount of remittances which they are sending to their family that lives in a rural area (Bresciani et al. 2002). However, a more common concern of rural households are climatic shocks which are particularly relevant in times of global climate change which is argued to bring about an increased number and severity of extreme weather events such as droughts, storms and unusually heavy rainfall (Trapp et al. 2007, Diffenbaugh et al. 2007, Emanuel 2005). Such weather calamities can be detrimental to crop harvests and livestock health. Occurring sporadically, they are a familiar part of farm households' life, similar to pest outbreaks (Oerke 2006), and personal illnesses, injuries and deaths (Dercon 2002).

As a result of being at risk to be affected by price shocks and other adversities, farm households are vulnerable to become poor or to fall deeper into poverty. Recent papers have applied simulation methods (Zezza et al. 2008, Dessus et al. 2008, Wodon et al 2008, Arndt et al. 2009), which are based on Deaton's approach (1989), and decomposition analysis (Valero-Gil 2008, World Bank 2008a) to evaluate the effect of price shocks on poverty. Such studies, which measure the aggregate effects of food prices on household well-being, e.g. by comparing rural versus urban consumers and producers, are useful especially for countries where poverty is widespread. However these studies also have their limitations.

First, they are not suitable for capturing the spatial pattern of poverty as it is typical for some of the emerging market economies in Asia. In these countries overall poverty has declined while in some areas "pockets of poverty" remain. Also poverty is stochastic rather than chronic, i.e. households move in and out of poverty depending on external factors (Justino and Litchfield 2003). Analyzing the effects of shocks such as the food price crisis on poverty on a regional or provincial level limits the use of econometric methods due to problems with sample size. Second, focusing exclusively on changes in food prices, they neglect the high correlation between input and output prices (Headey and Fan 2008). In fact, the impact of higher food prices on the net income from food production can be overestimated if increased costs of production are not taken into consideration. Third, they often model the effect of

hypothetical price shock scenarios instead of actual price changes, assuming that food prices increased at the same level across countries, regions or even food items (Headey and Fan 2008). However, price fluctuations are transmitted differently across and within countries depending on trade policy and transaction costs (Cudjoe et al. 2008, Ulimwengu et al. 2008). Fourth, they do not take into account possible allocation effects of price changes. Farm households may expand their food production when facing higher producer prices by increasing the land area allocated to food crops or intensifying production through the use of higher levels of inputs. Low profitable food crops may be substituted by high profitable food crops. Accordingly, households may decide to alter their pattern of food consumption by substituting expensive items with cheaper ones. Neglecting such allocation effects can cause a bias in estimating the effect of price fluctuations on poverty.

Given these limitations, normative models of typical rural households applying mathematical programming can be a useful complementary analytical tool. As pointed out by Brooks et al. (2008) farm household modeling is a suitable measure to assess micro-level impacts of exogenous conditions on household behavior. Such models can explicitly accommodate the distinctive features of a rural household in developing countries capturing their dual role as producer and consumer of food. They can account for interactions between resource endowments and constraints on the one hand and activities concerning production, on-farm and off-farm labor allocation, and consumption of home-produced as well as purchased goods on the other hand (Taylor and Adelman 2003). Furthermore such models are suitable to portray the various substitution effects of food price increase on the marginal products of household resources. Normative methods can also be a good tool to assess individual vulnerability instead of aggregate vulnerability and can thus be useful for a more refined targeting of social protection policy measures.

In this chapter the impact of price shocks on the vulnerability to poverty is measured taking into account multiple risks especially those arising from weather related factors which are most relevant for agricultural households. This study will therefore place the food price crisis in 2007/08 into the context of other risks and thus allow drawing lessons that could be useful from a scientific perspective and the point of view of policy. The objectives of the chapter therefore are:

1. to develop and test additional methodologies to measure vulnerability to poverty,
2. to assess vulnerability to poverty of a particular type of households namely those living in mountainous upland areas , in the case at hand in Thua Thien Hue province,
3. to analyze the impact of the food price shocks in 2007/2008 for a type of rural households in Vietnam that are believed to be especially at risk to fall into poverty.

The outline of the chapter looks as follows: the next section submits a brief description of the theoretical framework of the household-level analysis of vulnerability to poverty. Section 3 explains the methodology used for obtaining a mathematical programming-based vulnerability estimate. Section 4 provides a descriptive analysis of the farming system of typical farm households in the study area and of the transmission of the global price hikes to these households, and states the resulting model assumptions. In section 5 the empirical results of the mathematical programming model with regards to optimal household activity portfolios and vulnerability levels across the different scenarios are presented, and in the last section a summary is given and conclusions are drawn.

4.2 Theoretical framework

The analytical approach for assessing the vulnerability to poverty of agricultural households applied in this chapter draws upon the neo-classic household theory in developing countries. Following Nakajima (1970) the objective of farmers is to maximize their "subjective" utility, which encompasses the pursuit of multiple goals of different dimensions, i.e. economic, environmental, social and biophysical, which are often conflicting (Janssen and Ittersum 2007). The measurement and comparability of such objectives is usually difficult. Therefore simplifications are needed in order to ensure the tractability of quantitative models to be applied. Taking into account the scope of this study and the recommendations of other authors (Arriaza and Gomez-Limon 2003, Janssen and Ittersum 2007), profit and risk are chosen as criteria. This is meaningful since agricultural households in the mountainous upland of Thua Thien Hue are typically primarily concerned with subsistence production and the assurance of a minimum level of household income, achieved by avoiding larger risks, which enables them to cover their basic needs. The assumption of risk-averse behavior among farm households has been vindicated by numerous empirical studies (e.g. Binswanger 1980, Dillon and Scandizzo 1978).

The concept of vulnerability is based on the fact that poverty is a dynamic phenomenon. It takes into account that the welfare of households fluctuates over time due to the impact of unexpected negative events (shocks). This notion of uncertainty entails a differentiation between the expected well-being of a household, which is largely contingent upon the household's endowment of assets, and its realized well-being, which can be affected by (negative or positive) stochastic events. The general objective of vulnerability analysis is the *ex-ante* measurement of a household's probability to be below a certain welfare threshold in the future. Different approaches have been developed (Hoddinott and Quisumbing 2008) among which the concept of vulnerability as expected poverty (Chaudhuri et al. 2002, Christiaensen and Subbarao 2001) is the most frequently applied one. This approach extends the static Foster-Greer-Thorbecke poverty measures to make predictions about the likelihood of falling below a specified poverty line. In this study, the probability to fall below a relevant income poverty line will be predicted.

In order to analyze the effect of external price shocks on the resource allocation and the resulting vulnerability level of a farm household, a comprehensive farm household model is needed. In contrast to partial equilibrium models and computable general equilibrium models which take on the aggregate effects within the agricultural sector or the national economy, farm household modeling focuses on micro-level impacts of exogenous conditions on household behavioral responses (Brooks et al. 2008). A distinctive feature of a farm household is its dual role as a producer and consumer of agricultural production. As a producer, the household seeks to maximize farm profits, including implicit profits from self-produced and self-consumed goods, by choosing the optimal allocation of labor and other inputs subject to prices, resource endowments, financial and technological capacity. As a consumer, the household aims to maximize a discounted future stream of utility derived from the allocation of income from farm profits and wage earnings to the consumption of both purchased and self-produced commodities and services. Therefore decisions concerning own agricultural production, on-farm and off-farm labor allocation, and consumption of home-produced as well as purchased goods are inter-related. Farm household models take into account this interrelation in the form of objective function optimization, e.g. utility or household income maximization from different farm and consumption activities, subject to a range of constraints and the solution represents all endogenous variables as functions of exogenous variables (Taylor and Adelman 2003).

Farm household models recognize the inseparability of production and consumption and resolve the phenomenon of slow-moving or negative supply responses to food-price increases as well as the positive own-price elasticity of food demand in farm households. Increase in prices of food crops generally prompt households to expand the production of that crop. Price increases raise the marginal value product of all inputs including labor such that the household would allocate more household or hired labor and other input factors to on-farm production and less to off-farm wage employment or non-farm activities. The marketed surplus tends to increase since the opportunity cost of consuming home-produced food has risen. As a result, household income increases due to higher profit from farm production which leads to higher demand for food. However, the household at the same time faces higher food prices when purchasing consumption goods which may offset the positive income effect of

the price change (Ivanic and Martin 2010). In the end, the net effect on consumption depends on the household's utility function and the magnitude of the profit effect.

Several studies found that higher on-farm consumption can significantly dampen and possibly even reserve a positive effect of a price increase on the supply of food to the market (e.g. Kuroda and Yotopoulos 1978, Singh et al. 1986). In the developing countries high transaction costs in output and input markets can adversely encourage subsistence over commercial production. As Dyer et al. (2006) pointed out, shadow prices that influence opportunity costs of subsistence production are indirectly affected by prices in other markets especially those of input factors which they have direct interaction with such as labor and land. Furthermore, subsistence households may be more concerned about food security for home consumption than cash income from commercial sale of surplus and hence cautiously convert the resources towards the production of cash-crops. Such behavior is particularly relevant for households with poor resource endowment and limited substitutability among income-generating activities. For example, land quality may vary and be suitable only for particular crops which imply high cost of land conversion to accommodate other crops. Limitation of household on-farm labor and lack of access to seasonal hired labor markets make the intensification of cash-crop production more difficult. Together with the dynamics of input factor markets, increases in input prices for major factors such as fertilizer and fuel might counteract the increases in output prices of cash-crops as an increase in production requires intensification of input factors.

In addition, liquidity and risk constraints may limit small farm households' supply response to price changes and support diversification of less-risky activities with low economic returns. Hence, households must carefully respond to the positive price shocks by taking into account the resource constraints, risk perspective and the interactions of other prices in the markets. As a result, the net effect of an increase in the market price of food crops does not necessarily lead to a prompt increase in the market supply.

4.3 Mathematical risk programming

Most of the current literature that has empirically measured vulnerability, defined it as expected poverty, i.e. the probability that a household's future consumption or income will fall below the poverty line. To estimate vulnerability, econometric approaches have been used which are often based on cross section data (e.g. Chaudhuri et al., 2002). An alternative approach which is proposed here is to rely on mathematical programming (MP) models which are based on the construct of typical rural households as described in section 2. MP combines a vector of decision variables, which reflect a set of income-generating activities of a typical rural household, such that an objective function is maximized subject to specified resource and behavioral constraints. To reflect the general socioeconomic conditions of poor households in the respective provinces we assume risk averse behavior such that a typical farm household seeks to maximize household income subject to achieving a minimum level of income determined by basic consumption needs. The MP model allows to explicitly incorporating risk, and hereby the distribution of household income for optimal farm household portfolios under different scenarios can be derived. Cumulative distribution functions of household income can be compared to the poverty line and thus allow deriving the probability of a typical household to be poor in some future period.

Various techniques for incorporating risk-averse behavior into mathematical programming models are available, with quadratic programming (Markowitz 1952, Freund 1956) and linear approximation approaches such as MOTAD (Hazell 1971) being the most commonly used ones. Alternative techniques are safety-first models, mean-standard deviation models, game theory models, and models which capture risk in the constraint set such as discrete stochastic and chance-constrained programming (Hazell and Norton 1986). In this study Tauer's (1983) Target MOTAD model is used which is particularly suitable when the risk of being affected by shocks is large, either due to an inherently risky environment, or due to a high level of poverty of the farm household and a related poor endowment of assets that can be depleted in times of hardship.

The Target MOTAD model can be specified as follows:

$$\max \sum_j \overline{c_j} X_j \tag{9}$$

such that:

$$Y_0 - \sum_j c_{jt} X_j - Z_t^- \leq 0, \ \textit{for all } t \tag{10}$$

$$\sum_t p_t Z_t^- \leq \lambda \tag{11}$$

$$\sum_j a_{ij} X_j \leq b_i, \ \textit{for all } i \tag{12}$$

$$X_j, Z_t^- \geq 0, \ \textit{for all } j,t \tag{13}$$

where $\overline{c_j}$ is the expected mean gross margin per unit of the j^{th} household activity across all states of shock occurrence, X_j is the level of the j^{th} household activity, Y_0 is the target income to be achieved (e.g. the minimum required income for the farm household to survive), c_{jt} is the expected gross margin per unit of the j^{th} activity in the t^{th} state of shock occurrence, Z_t^- is the negative income deviation from the expected mean gross margin in the t^{th} state of shock occurrence, p_t is the probability of occurrence of state of shock occurrence t, λ is the maximum average shortfall of income which still enables a satisfactory level of compliance with the target income, a_{ij} is the technical coefficient of the i^{th} resource required to achieve X_j, and b_i is the resource constraint level of i^{th} resource (McCarl and Spreen 1997). By parameterization of λ, a set of efficient farm plans with the maximum possible value of household income for any specified level of compliance with the target income is obtained. Households with the highest risk aversion may choose the farm plan related to the smallest possible level of compliance with the target income. Less risk-averse farm households might prefer farm plans promising higher levels of expected income but also higher levels of compliance with the target income providing that the absolute level of compliance with the target income remains sufficiently small.

The Target MOTAD model developed here covers a one-year time period and includes the main income-generating activities of the typical household as specified in section 2. Resource and consumption constraints and the seasonality restrictions of farming activities were incorporated in the model. Shock events were considered in the model, first, by identifying the most relevant weather-related shocks e.g. unusually cold weather, drought, and unusually heavy rainfall and storm. Hence 8 weather-related shock scenarios are considered. The shock events are specified by month of occurrence, effect on crops and corresponding yield loss. Corresponding crop gross margins were quantified and the subjective probability of occurrence of each shock type was determined based on the expectations of the surveyed households. Thereby two different sets of prices were used. One consisting of farm gate and market prices for crops and inputs in 2007 (all converted to PPP$ in 2005), representing the situation before the price hike. And a second one consisting of farm gate and market prices for crops and inputs in 2008, representing the situation during the price hike. This information was then used to construct the set of possible states of shock occurrence (see Appendix B for gross margins across and probabilities of different states of weather shock occurrence for 2007 and 2008 prices). Assuming that distinct shock types are independent of each other, the probability of each state of shock occurrence was determined. The expected gross margin of each cropping activity is the mean gross margin per hectare over all possible states of shock occurrence. The deviations from mean gross margin in each state of shock occurrence were calculated, and applied in the Target MOTAD model to approximate the standard deviations of gross margins for each activity.

Solving the two Target MOTAD model[12] scenarios yielded the optimal activity portfolio of the farm household, the corresponding expected mean and variance total household income, and the total household income that would be realized in each state of shock occurrence in both survey years 2007 and 2008. Using these results, the cumulative distribution function (CDF) of total household income in both years was computed. The CDF of total household income can be written as:

$$F(x) = P(i \leq x) \tag{14}$$

[12] The *General Algebraic Modelling System* (*GAMS*) was used to run the model. See Appendices C to F for the LP matrices for 2007 and 2008 prices.

where i is a random variable of the discrete type, representing total household income, with probability density function

$$f(x) = P(i = x), x \in \Re . \quad (15)$$

The value of the CDF at each level x of total household income i indicates the probability that total household income is smaller than or equal to x. If $x = PL$ and PL is specified as the poverty line, then the value of the CDF at PL gives the probability of the household to be poor. Following the concept of vulnerability as expected poverty (Chaudhuri et al. 2002, Christiansen and Subbarao 2001) and assuming that i is constructed based on another standard normal random variable, the expected mean of total household income, and the expected variance of total household income, this gives the vulnerability V_t of the household at time t, which can be formally specified as:

$$V_t = P(i_{t+1} \leq PL) \quad (16)$$

where i_{t+1} is the household's level of income at time $t+1$, and PL is the income poverty line. The impact of price changes between 2007 and 2008 on household vulnerability to poverty can be seen by plotting the CDF of each year.

4.4 Model assumptions

In Table 4.1 the typical farm household which was described in general in chapter 2 is presented using a number of household characteristics like household size, agricultural labor ratio, labor capacity, land endowment, consumption needs and the frequency of shocks experienced. All statistics are used as model assumptions except for the frequency of shocks which is given as background information. The values in Table 4.1 are median values in order to control for outlying observations, except for labor capacity and rice consumption which are imputed values. The frequencies of shocks derived from the respondents' subjective assessment are presented as mean values.

A typical agricultural household in Vietnam usually consists of 4-5 members and is income poor when compared with poverty line for rural Vietnam. In order to represent a realistic household roster, the model household is assumed to comprise 2 adult members, 1 adolescent member and 1 child. All income-generating household members are engaged in agriculture. For deriving the annual labor capacity it was assumed that each household member is unable to work every day due to weather restrictions, social obligation days, illnesses, housework obligations and school time that affect each member on a different scale[13]. The model accounts for the fact that the adolescent household member is only able to carry out physically light work whereas the two adult members possess the ability to engage in physically more demanding activities (e.g. forest extraction).

Total land endowment is seemingly large, however only a small share can be used for agricultural production while the remaining part consists of forest, shrubs and bare hills practically unusable for crop production under the current state of technology. The annual household consumption need of rice, which is the major staple food, was deduced from the annual per capita rice consumption figures from FAOSTAT[14]. The household's required annual consumption of purchased non-rice goods were set at 600 PPP$. The model household frequently suffers from covariate weather shocks by

[13] Annual hard labor capacity = 300 person days (male adult member) + 200 person days (female adult member) = 500 person days. Annual light labor capacity = 150 person days (adolescent member).
[14] http://faostat.fao.org.

drought, storm, flooding and cold weather as well as idiosyncratic human health shocks.

Table 4.1: Characteristics of the model household

Characteristic	Unit	
Monthly per capita income	(PPP$)	34.90
Household size	(persons)	4.00
Agricultural member ratio	(%)	100.00
Annual family labor capacity		
Hard labor	(person days)	500.00
Light labor	(person days)	150.00
Land endowment		
Total	(ha)	1.70
Crop land	(ha)	0.16
Annual consumption requirements		
Rice	(kg)	1012.00
Corn (own production)	(kg)	12.50
Banana (own production)	(branches)	2.00
Non-rice purchased consumption	(PPP$)	606.20
Shocks 2002-2008		
Total	(number)	3.45
Illness	(number)	0.32
Flood	(number)	0.23
Unusually heavy rainfall	(number)	0.27
Storm	(number)	0.86
Unusually cold weather	(number)	0.41

Source: DFGFOR756 base survey and in-depth survey Thua Thien Hue province.
Note: n=22.

Table 4.2 shows the crop production technologies that enter the model. The main crops cultivated by the typical farm household are spring rice, autumn rice, cassava, corn and banana. The yield levels given in Table 4.2 are weighted averages across the modeled states of weather shock occurrence. Yield levels are low as compared to average Vietnamese yield levels of the respective crops (FAOSTAT 2010) which is due to the relatively poor soil fertility in the mountainous upland of Vietnam North Central Coast region (World Bank 2005). To ensure food security, households preserve some amount of yield for subsistence consumption and sell the surplus for cash income if marketing opportunities exist. Growing upland rice as a cash crop to be sold in lowlands is not feasible due to differences in consumption preferences between consumers in mountainous areas and in lowlands. Due to the relatively low

yield levels of rice grown, households in mountainous areas generally must purchase additional rice at the market in order to satisfy their consumption needs (Pandey et al. 2006).

Because mechanization is basically non-existent in the mountainous areas all crops are rather labor-intensive. Thus, no fuel is required for agricultural production. However, chemical fertilizer is used for spring rice and corn production whereas organic fertilizer is not applied at all due to a lack of livestock. Household possess only small quantities of livestock and do not have sufficient knowledge about crop-livestock interaction. Other material inputs used for the production of some crops are pesticides and herbicides. The types of inputs typically used are an important determinant of the effect that fluctuations in input prices can have on household welfare.

Table 4.2: Production technology and input intensity of major crops (per hectare)

	Crop type				
	Spring rice	**Autumn rice**	**Cassava**	**Corn**	**Banana**
Yield (kg)	2478.6	2934.8	7250.0	1120.2	330.6
Input use					
Seeds (kg)	120.0	120.0	516.7	40.0	0.0
Fertilizer (kg)					
Chemical	550.0	0.0	0.0	750.0	0.0
Organic	0.0	0.0	0.0	0.0	0.0
Pesticide (litre)	26.3	0.0	0.0	13.3	0.0
Herbicide (bags)	0.0	6.7	0.0	0.0	0.0
Fuel (liter)	0.0	0.0	0.0	0.0	0.0
Family Labor (person days)	510.9	256.1	816.0	543.0	338.5

Source: In-depth survey Thua Thien Hue province.

In order to calculate gross margins for the different crops before and during the modeled price hike, respective prices for both inputs and outputs were required. Figure 4.1 shows the observed changes in factor and product prices between 2007 and 2008. The price changes were observed from the additional data collection activity in the province of Thua Thien Hue (see chapter 2). Results show that the consumer price of rice increased sharply indicating that the transmission of the price hike of the rice world market was effective in Vietnam. For the model household, taking into account fluctuations in the consumer price of rice is sufficient as no market for selling own-

produced rice exists in the study area and households are net-buyers of rice. This suggests that some households in Vietnam may not have benefited from the rise in rice prices. Only cassava, corn and banana can be sold. However, the respective increase in producer prices was comparatively small, ranging from almost 0% (cassava) to up to 10% (corn). On the input side chemical fertilizer prices increased about 50%, suggesting a possible negative effect on household welfare.

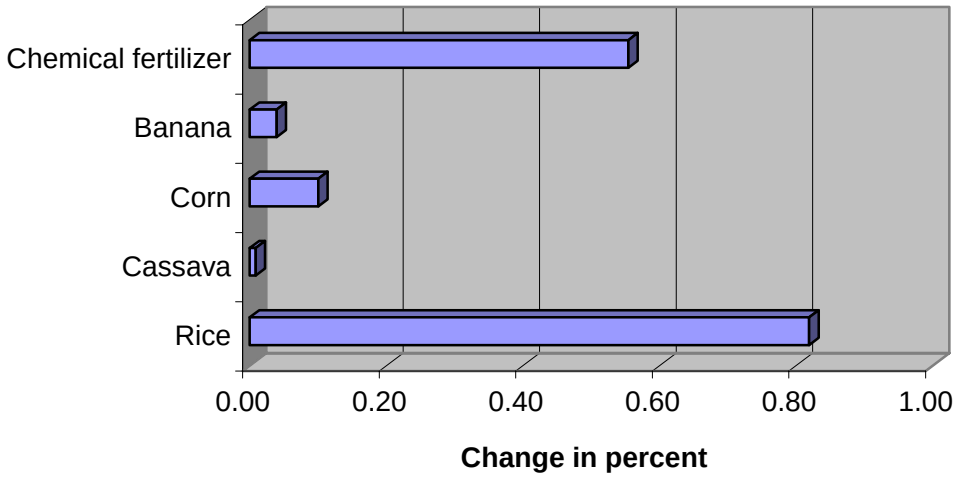

Figure 4.1: Price changes of output and input 2007-2008

Source: In-depth survey Thua Thien Hue province.

Note: Banana, corn and cassava = producer prices. Rice = consumer price.

Table 4.3 presents the resulting gross margins of crops in all possible states of weather shock occurrence based on both 2007 and 2008 prices. Results indicate that gross margins are generally highest for autumn rice followed by either banana (based on 2007 prices) or spring rice (based on 2008 prices). Rice gross margins rise sharply from 2007 to 2008 while only a slight increase occurs with regards to banana and cassava. Corn production generally yields a negative gross margins which suggests that its production as was observed in the study area may be motivated by factors other than profit maximization.

Table 4.3: Gross margins across states of weather shock occurrence

a) 2007 prices

Scenario	Gross margins in PPP$ Spring rice	Autumn rice	Cassava	Corn	Banana	Probability of the scenario
No shock	816	1633	988	-272	1482	0.505
Cold shock	196	1633	988	-1130	613	0.089
Drought shock	-59	1633	988	-1130	1482	0.111
Flood/rain/storm shock	816	679	0	-272	0	0.192
Cold + Drought shock	-615	1633	988	-1130	613	0.020
Cold + Flood/rain/storm shock	196	679	0	-1130	0	0.034
Drought + Flood/rain/storm shock	-59	679	0	-1130	0	0.042
All shocks	-615	679	0	-1130	0	0.007
Expected value	567.1	1370.7	716.3	-532.3	979.9	
Variance	157683.9	181393.1	194618.7	155261.8	434090.0	
Standard deviation	397.1	425.9	441.2	394.0	658.9	

b) 2008 prices

Scenario	Gross margins in PPP$ Spring rice	Autumn rice	Cassava	Corn	Banana	Probability of the scenario
No shock	1448	2746	997	-725	1540	0.505
Cold shock	414	2746	997	-1598	637	0.089
Drought shock	-10	2746	997	-1598	1540	0.111
Flood/rain/storm shock	1448	1155	0	-725	0	0.192
Cold + Drought shock	-938	2746	997	-1598	637	0.020
Cold + Flood/rain/storm shock	414	1155	0	-1598	0	0.034
Drought + Flood/rain/storm shock	-10	1155	0	-1598	0	0.042
All shocks	-938	1155	0	-1598	0	0.007
Expected value	1033.6	2308.1	722.5	-989.2	1018.4	
Variance	438726.8	504693.3	198021.6	161184.1	468854.0	
Standard deviation	662.4	710.4	445.0	401.5	684.7	

Source: In-depth survey Thua Thien Hue province.

As pointed out above, the key motivation for using a Target MOTAD approach in the mathematical programming model is the assumption of risk-averse behavior of the model household. This assumption is based on findings of the empirical study in the mountainous upland of Thua Thien Hue province which included a self-assessment of the interview respondents' attitude toward risk. In particular, each respondent was asked whether he is generally a person who is fully prepared to take risks or a person who tries to avoid taking risk. Respondents could indicate there self-assessment by choosing a number on a scale from 0 (=unwilling to take risk) to 10 (fully prepared to take risk).

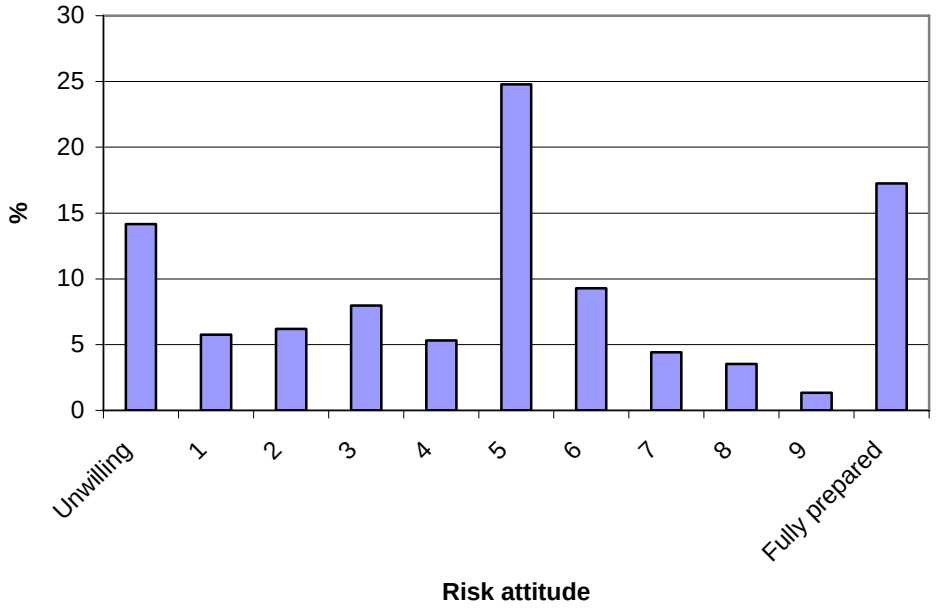

Figure 4.2: Self-assessment of risk attitude among households in the mountainous upland of Thua Thien Hue province

Source: DFGFOR756 base survey.

Note: n=226.

The outcome of the self-assessment of risk attitude is presented in Figure 4.2. Results indicate that only a relatively small fraction of households of about 17% is fully prepared to take risk while the majority of households stated some level of risk aversion which ranges from slightly risk averse to highly risk averse. This finding supports the decision to apply a Target MOTAD model in order to capture risk-averse decision-making behavior.

4.5 Results

Based on the assumptions established for the typical farm household in the mountainous upland of Thua Thien Hue province, a target MOTAD model was solved. Different levels of risk aversion were postulated and a comparison of the situation with and without price shocks was carried out.

Assuming a high risk aversion, expressed as zero shortfall from the required consumption levels (λ=0), leads to infeasible solutions in the Vietnam case. That suggests that some households in Vietnam must generate some share of their consumption from natural resources, i.e. sometimes illegal logging. This is especially the case if households are confronted with negative shocks (Völker and Waibel 2010). However, the model presented in this chapter shows that when the degree of risk aversion is lowered a feasible solution can be generated suggesting that the pressure on natural resources will be reduced.

In Table 4.4 the allocation effect of the 2008 price shock for the typical household is presented. The model is solved for a household with an assumed low degree of risk aversion (λ=600). The optimal solution provides the expected household income, the standard deviation of income and the allocation of the household's resources over the different income generating activities. Optimal solutions are generated for a situation for the 2007 and the 2008 price scenario.

Results show that a large substitution effect takes place. Vietnamese households as specified in the model substitute spring and autumn rice by banana to a significant degree. This is well in line with the price changes observed from Figure 4.1. An agricultural household producing under remote upland conditions does not benefit from higher producer prices of rice, due to a lack of marketing opportunities and especially higher input prices of chemical fertilizer. The latter limited the increase in net revenue of rice production. Thus, both the marginal costs of rice production and the purchase costs of rice increased. The only crop in the portfolio that is unaffected from higher input prices and that experienced slightly higher output process is banana. Hence the economically optimal adjustment taking risk into account is the expansion of banana production. However, in interpreting these results it is important to bare in

mind that the model abstracts from the time needed from planting perennial crops such as banana until the first harvest season. Thus, the crop portfolio that is based on 2008 prices rather indicates that the tendency of the model household is to cultivate more banana instead of rice. Realizing such an adjusted crop portfolio requires a suitable amount of time and is not possible from one year to the other.

Table 4.4: Optimal farm household activity portfolios across price scenarios for households with low risk aversion (λ=600)

Activity	*Unit*	2007 prices	2008 prices
Spring rice	ha	0.034	0.000
Autumn rice	ha	0.034	0.000
Corn	ha	0.011	0.011
Banana	ha	0.113	0.146
Forest extraction	PPP$	755.060	755.060

Source: Own calculations.

Note: Inconsistencies are due to rounding errors. Spring and autumn rice are rotated on the same land area.

Figure 4.3 shows the effect of the price shock on the distribution of household income across different states of weather shock occurrence. It becomes clear that the type of household specified in our model was already vulnerable prior to the 2008 price shock. However the food price crisis which is supposed to be a positive shock for agricultural producers has made certain types of households in Vietnam, namely those portrayed in the model presented in this chapter, more vulnerable to poverty. While the vulnerability level was at 29% in the before-crisis price situation for the mountain farmers, the hike in food prices has increased vulnerability to 100% thus throwing this type of agricultural households into poverty. It is also evident from Figure 4.3 that for some shock scenarios a considerable poverty gap has existed which was further augmented by the price shock.

It must be added that the expected income deviates from the household income in Table 4.1. This is not surprising as the typical household is not equivalent with the median household identified for the household group used in this sample. When comparing the discrete cumulative distribution functions for the with and without price increase scenarios, stochastic dominance of first degree can be postulated. This

means that under all other conditions like weather related shocks higher food prices decrease the well-being of the type of poor farm households in Vietnam that are portrayed in the model presented above. Again, in drawing such conclusions it is important to take into account the abstraction of the real world situation by the model. In reality higher food prices may push households even deeper into poverty during a transition period as households need time to implement the adjusted, risk-efficient crop portfolio that includes more land allocated to banana instead of rice production.

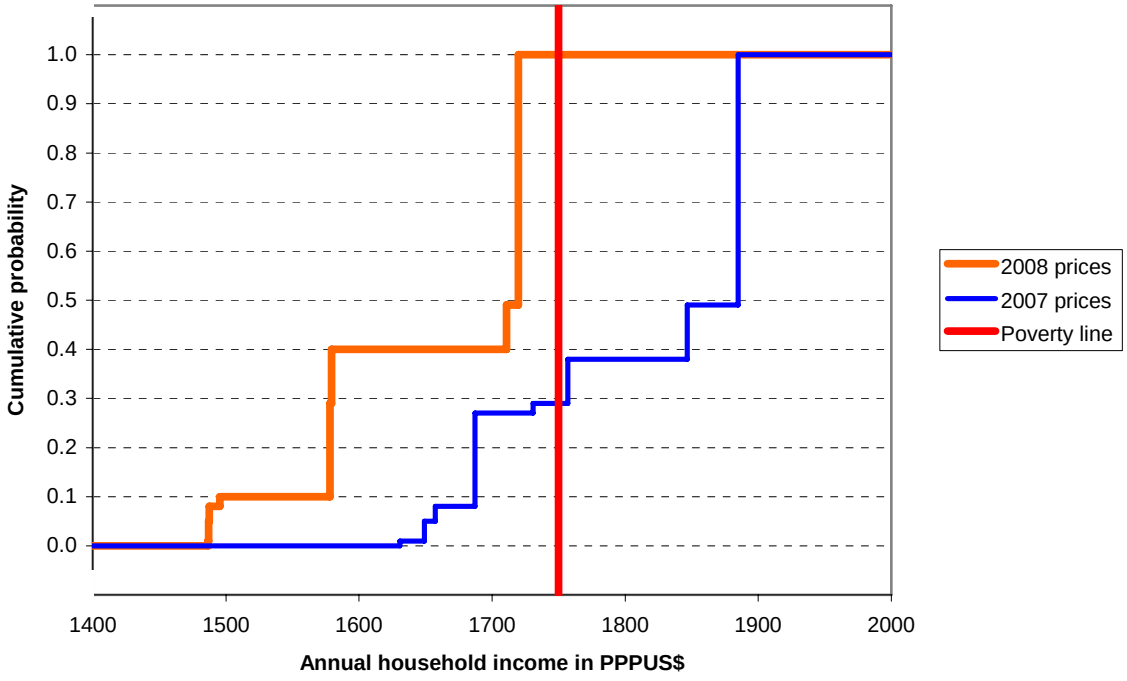

Figure 4.3: Discrete cumulative distribution functions of household income among and across price scenarios (Target deviation ≤ 600)

Source: Own calculations.

4.6 Summary, conclusions and recommendations

In this chapter the impact of the 2008 food price shocks on the vulnerability to poverty of poor rural households in Vietnam is assessed using a normative modeling approach. The objectives were threefold, namely first to develop and test additional methodologies to measure vulnerability to poverty, second to assess vulnerability to poverty for a particular group of farm households in Vietnam and third to analyze the impact of the 2008 food price shocks by means of a normative model. A classic target MOTAD mathematical programming model was developed for a specified household type in Vietnam. The households were defined as being typical for the poorer segment of rural households living in remote mountainous areas of the three provinces included in the DFG project (see chapter 2). The data established in the model assumptions were collected in complementary in-depth surveys in the province of Thua Thien Hue, derived from the general data base of the project (see www.vulnerability-asia.uni-hannover.de). The selected households were based on criteria like (i) household income below the poverty line, (ii) households engaged in own agricultural production, (iii) households with shock experience and (iv) typical for the respective province with regards to income generating activities, i.e. purely agricultural households.

As regards the first objective it can be stated that normative models have the advantage to simultaneously consider various shocks such as economic and weather related shocks in a theoretically consistent framework. Although one can question the behavioral assumptions entered in the model, the incorporation of risk through the Target MOTAD approach is a plausible representation of the degree of risk aversion. In fact, the analysis of risk questions in the survey revealed that the majority of respondents are risk averse. Furthermore the flexibility of constructing typical households provides a direct way to calculate individual vulnerability measures for subsets of household types. In this way conclusions can be drawn for poverty reduction policies of smaller administrative units which would be difficult with the use of positive econometric methods due to the problem of small sample size.

For the second objective model results of the model show that mountain households are vulnerable to poverty, having a 29% probability of being poor in a normal year. In

comparison to the cross section based method of vulnerability computations (Chaudhuri et al. 2002) the calculated vulnerability measure is believed to be more situation specific. Also the baseline solution of the normative model can be used as a benchmark for impact assessment of policy interventions or external shocks such as food price hikes analyzed here. This has facilitated the main objective of this chapter which is to assess the impacts of the 2008 food price hike in Vietnam. Results are consistent with the findings of other research (e.g. Phung Duc and Waibel 2010b) which found that the food price hike of 2008 has reduced overall poverty but has made the very poor people poorer. This research shows that this type of rural households have also become much more vulnerable. Agricultural households in the mountain areas of Vietnam are among the losers of higher food prices. From a methodological point of view, the result of this modeling exercise supports the findings of other household studies in developing countries (e.g. Kuroda and Yotopoulos 1978, Singh et al. 1986, Dyer et al. 2006) that household consumption requirements can reverse a positive price effect due to market imperfections.

In conclusion this chapter on modeling the impact of the food price crisis provides a good starting point for further analysis when formulating different household systems (e.g. commercial oriented farms, different locations with different natural environments). The methodology can also be used to test the impact of policy interventions and the introduction of new technologies on vulnerability to poverty.

Concerning policy implications for the mountainous upland of Thua Thien Hue province, this chapter discloses several possible constraints that households face in their agricultural production such as a limited endowment with agricultural land, missing access to certain input factors, such as machinery and organic fertilizer, as well as missing realistic alternative options to generate income such as other crop or livestock products or the engagement in off-farm wage labor and non-farm self-employment. Further investigation is needed here in order to better understanding the exact nature and underlying causes of such entry-barriers to effective risk management and shock coping in order to guide possible policy interventions which can help to overcome such impediments to efficient risk-mitigation behavior.

Chapter 5[15]

Climate risk perception and ex-ante management strategies

5.1 Introduction

In emerging market economies vulnerability to poverty is a common phenomenon. People who have escaped poverty may fall back because of natural disasters, economic and political crisis. Especially rural households are often subject to high future risks due to an inadequate ability to use ex-ante risk management and ex-post shock coping strategies (Chaudhuri et al. 2002, Kochar 1995, Kozel et al. 2008). Vietnam and Thailand are two typical examples of countries where vulnerability to poverty remains an issue in spite of successful advances in chronic poverty reduction (ADB 2008, UNDP 2008, World Bank 2003, World Bank 2008b). Major risk factors for the rural areas in Vietnam are climate change, which among other effects brings about an increased frequency and severity of extreme weather events (ADB 2009, IPCC 2007), and continued environmental degradation (Millennium Ecosystem Assessment 2005), which destroys natural resources that are crucial for the livelihoods of poor and vulnerable households, especially those living in remote, rural areas (World Bank 2005). As a consequence, Vietnam is faced with high costs of adapting to the adverse effects believed to be associated with climate change (ADB 2009). The negative impact of shocks on welfare depends on the ability of households to apply effective ex-ante mitigation strategies such as income diversification, adoption of new agricultural technologies, investment in physical, human and financial capital, as well as building up buffer stocks and savings (Dercon 2002, Morduch 1995, Townsend 1995). Adoption of such strategies is a function of socio-

[15] This chapter is based on the paper *Climate risk perception and ex-ante mitigation strategies of rural households in Thailand & Vietnam*, by Songporne Tongruksawattana, Marc Völker, Bernd Hardeweg and Hermann Waibel, which has been accepted for presentation at the 117th EAAE Seminar, "Climate Change, Food Security and Resilience of Food and Agricultural Systems", University of Hohenheim, November 25 – 27, 2010. This chapter comprises a more detailed description of shocks and risks as compared to the paper version.

economic household and location characteristics including, among others, knowledge, market and government incentives, and the decision makers' perception of risk (Dercon 2002, Sivakumar and Motha 2007).

In many studies related to risk and agriculture, historical data on rainfall, temperature and other environmental variables have been used for surveillance and forecasting models (Boisvert and McCarl 1990, Musser et al. 1984). One disadvantage of models based on objective information is that they generally do not take into account individual perceptions and preferences of the decision makers and hence are less suitable for deriving policy recommendations (Anderson et al. 1977). Also with conclusions drawn from the outcome of such models it is difficult to influence the behavior of decision makers, especially if these are small scale farmers. It is therefore important to complement normative models with those which are based on subjective perceptions of the decision makers. In relation to climate change and agriculture it is important to understand how rural households experience environmental change, i.e. what is their subjective perception of both the severity and the likelihood of climate related events.

Although risk perception is a well-established field of research which originated in about the mid-twentieth century (Raj Dahal 2008), climate risk with regards to rural farm households in developing countries has rarely been addressed. Existing studies mainly have focused on the developed world including both technological risks, e.g. posed by hazardous facilities such as nuclear power plants (Sjoberg 2000), and physical hazards such as flooding (Kates 1962), earthquake (Mileti and Darlington 1997), wildfire (Gardner et al. 1987), volcanic eruption (Gregg et al. 2004), drought (Taylor et al. 1988), snow (Earney and Knowles 1974), tornado and cyclone (Hanson et al. 1979), and hurricane (Cross 1980). Research on risk perception is dominated by two different theories: the psychometric paradigm which assumes that risk is inherently subjective and cultural theory (Sjöberg et al. 2004). Risk research studies have aimed at identifying and psychologically explaining factors determining individual risk perception (Smith 1979) as well as examining the relationship between risk perception and mitigation behavior (Takao et al. 2004).

Few studies have focused on climate risk in developing countries. Paul (1984) found that perception of flood risk among Bangladeshi farm households was positively affected by their experience with past floods, and that farm households applied traditional techniques in order to cope with the adverse effects of both normal and abnormal floods. Findings of a study conducted by Ologunorisa and Adeyemo (2005) indicate that floodplain residents in the Niger Delta, though being familiar with the main causes of floods, lack important knowledge about flood frequencies and alleviation schemes, and are often unable to migrate to less flood-prone areas because of their occupations in agriculture and fishery, as well as the high costs of migration. Wong and Zhao (2001) found that Chinese flood victims favor functional adjustments to mitigate the adverse effects of floods over engineering structures constructed to control floods physically.

The objective of this study is to assess the effect of climate shock experience on climate risk perception of rural households in Central Vietnam and Northeastern Thailand as well as the relationship between the perception of climate risk and the use of ex-ante risk management strategies. The following questions are investigated:

1. What is the status of climate shock experience, risk perception and ex-ante risk management strategy usage of households in the study areas?
2. Do climate shock victims perceive the risk of being affected by such events to be higher than other households?
3. How do climate risk perception and other factors affect the households' decision to apply any ex-ante risk management actions?
4. What effect does climate risk perception have on the use of specific main ex-ante risk management strategies?

This chapter is organized as follows: the next section presents results of a descriptive analysis of households' climate shock experience and risk perception, as well as major socio-demographic characteristics. In section 3 the methodology used for empirically testing the relationship between climate shock experience and risk perception, as well as between climate risk perception and the adoption of ex-ante risk management strategies is explained. section 4 presents the results of an econometric analysis, and the last section concludes.

5.2 Descriptive statistics

The empirical analysis comprises a cross-country comparison between households in three Central Vietnamese provinces (Dak Lak, Ha Tinh and Thua Thien Hue) and three Northeastern Thai provinces (Buri Ram, Nakhon Phanom and Ubon Ratchathani). The comparison with data collected in Thailand is adding value to the assessment for Vietnam because it can serve as a counterfactual. Rural households in the study area were affected by different types of unexpected adversities, including climatic, biological, socio-demographic as well as economic shocks (Table 5.1). Adverse climatic shocks were the most prevalent type of calamity experienced by households, with events like flooding, unusually heavy rainfall, storm, drought and unusually cold weather having affected about three quarters of the rural population in Vietnam and more than half in Thailand. On average, each household in both countries was affected by about two climate shocks during the 7-years reference period between 2002 and 2008 but Vietnamese households assessed the severity of shock incidents to having been higher than Thai households. However, standard deviations of reported shock frequency and severity show that some households suffered a higher number or severity of shocks while others were not affected at all or only by events of low severity.

A similar variation in shock frequency and severity can be observed for other shock types. Socio-demographic shocks were reported with the second-highest frequency in both countries with illnesses of household members ranked high while other events, such as deaths of household members, were only experienced by a small share of households. Biological shocks, such as crop pests and livestock diseases, affected about 40% of rural households in Vietnam but only 15% in Thailand. Last but not least, economic adversities, especially unexpected fluctuations in input and output prices, made up for a substantial proportion in Thailand (27.5%) but generally played a minor role in Vietnam with only slightly more than 9% of households affected.

Table 5.1: Shock events experienced between 2002 and 2008 (n[1]=2146 for Vietnam & 2127 for Thailand)

Type of shock	Households (%)		Shocks per household (Ø)		Shock severity[2] (Ø)	
	VN	*TH*	*VN*	*TH*	*VN*	*TH*
Climatic	**75.2**	**53.9**	**1.7** ***(0.8)***	**1.9** ***(1.4)***	**2.7** ***(0.5)***	**0.9** ***(0.5)***
Flooding	34.3	34.8	1.2 *(0.5)*	1.6 *(1.3)*	2.7 *(0.5)*	0.7 *(0.5)*
Drought	27.3	41.9	1.2 *(0.5)*	1.6 *(1.1)*	2.7 *(0.5)*	0.8 *(0.5)*
Heavy rainfall	14.9	2.5	1.0 *(0.2)*	1.4 *(1.3)*	2.6 *(0.6)*	0.5 *(0.4)*
Erosion	1.0	0.3	1.0 *(0.2)*	1.0 *(0.0)*	2.9 *(0.4)*	0.2 *(0.1)*
Storm	15.9	2.1	1.0 *(0.2)*	1.0 *(0.2)*	2.6 *(0.6)*	0.4 *(0.3)*
Snow/ice rain	16.5	0.5	1.0 *(0.0)*	1.1 *(0.3)*	2.6 *(0.5)*	0.5 *(0.4)*
Biological	**40.2**	**15.3**	**1.3** ***(0.6)***	**1.3** ***(0.6)***	**2.6** ***(0.5)***	**0.6** ***(0.4)***
Crop pest	19.3	12.8	1.1 *(0.4)*	1.2 *(0.6)*	2.6 *(0.5)*	0.5 *(0.4)*
Storage pest	1.7	1.9	1.0 *(0.2)*	1.1 *(0.2)*	2.4 *(0.8)*	0.4 *(0.3)*
Livestock disease	24.9	2.0	1.2 *(0.5)*	1.2 *(0.6)*	2.7 *(0.5)*	0.6 *(0.4)*
Socio-demographic	**60.1**	**51.2**	**1.6** ***(0.8)***	**1.8** ***(1.3)***	**2.6** ***(0.5)***	**0.9** ***(0.7)***
Illness	45.3	29.9	1.3 *(0.6)*	1.4 *(1.0)*	2.7 *(0.5)*	0.8 *(0.6)*
Death	7.3	9.4	1.1 *(0.3)*	1.4 *(0.8)*	2.8 *(0.5)*	0.6 *(0.5)*
Household dynamics	7.8	3.4	1.1 *(0.4)*	1.3 *(0.8)*	2.1 *(0.7)*	0.8 *(0.7)*
Household ceremony	6.1	6.9	1.0 *(0.2)*	1.2 *(0.6)*	2.3 *(0.7)*	0.7 *(0.7)*
Household damage	3.4	3.8	1.0 *(0.0)*	1.3 *(0.9)*	2.6 *(0.6)*	0.5 *(0.4)*
Theft	4.2	2.8	1.1 *(0.2)*	1.1 *(0.4)*	2.3 *(0.7)*	0.7 *(0.7)*
Accident	2.9	6.1	1.1 *(0.4)*	1.1 *(0.6)*	2.7 *(0.5)*	0.7 *(0.8)*
Neighbour conflict	-	2.1	- -	1.2 *(0.5)*	- -	0.5 *(0.5)*
Law suit	-	1.8	- -	1.3 *(0.8)*	- -	0.5 *(0.3)*
Was cheated	-	2.4	- -	1.1 *(0.4)*	- -	0.6 *(0.7)*
Economic	**9.2**	**27.5**	**1.1** ***(0.4)***	**1.4** ***(0.9)***	**2.7** ***(0.5)***	**0.6** ***(0.5)***
Remittances stop	-	1.6	- -	1.1 *(0.6)*	- -	0.5 *(0.4)*
Collapse of business	1.2	4.4	1.1 *(0.3)*	1.1 *(0.5)*	2.8 *(0.3)*	0.6 *(0.6)*
Rise of interest rates	0.4	5.6	1.0 *(0.0)*	1.4 *(0.8)*	2.8 *(0.7)*	0.5 *(0.3)*
Fall in output prices	4.3	3.9	1.1 *(0.3)*	1.1 *(0.4)*	2.8 *(0.4)*	0.4 *(0.4)*
Rise in input prices	2.4	16.3	1.0 *(0.2)*	1.1 *(0.5)*	2.4 *(0.6)*	0.5 *(0.5)*
Market regulations	0.4	0.5	1.0 *(0.0)*	1.4 *(0.8)*	2.8 *(0.5)*	0.3 *(0.3)*

Source: DFGFOR756 base survey.

Note: [1] Complete sample of households with at least 1 nucleus member which were interviewed in both survey waves. Number of shocks and shock severity were computed exclusively for households affected by the respective shock type. Standard deviations are presented in brackets. [2] Shock severity measured as ordinal scale from 0 (=no impact) to 3 (=high severity).

Some striking differences exist between the households' experience of shocks between 2002 and 2008 and their perception of future risk (Table 5.2). Based on their experience of adversities in the 7-years reference period, households appear to be quite pessimistic about the incidence of shocks in a future reference period of 5 years from 2008 to 2013. Results indicate that not only those shock types which have been experienced by large shares of the population are expected to happen in the future by

still more households, but that even adversities which hardly affected any household are feared by considerable shares of the rural households with an average expected frequency for all risk types of at least once per year and low to medium severity on income and asset.

Table 5.2: Risk events perceived in 2008 (n[1]=2146 for Vietnam & 2127 for Thailand)

Type of risk	Households (%)		Expected frequency (Ø)		Expected severity[2] (Ø) on… ...income		...assets	
	VN	*TH*	*VN*	*TH*	*VN*	*TH*	*VN*	*TH*
Climatic	**90.0**	**73.2**	**8.4 (6.4)**	**4.2 (4.2)**	**2.3 (0.8)**	**2.1 (0.9)**	**0.9 (1.0)**	**1.2 (1.2)**
Flooding	52.7	22.6	3.9 (1.6)	3.2 (1.7)	2.5 (0.8)	2.3 (0.9)	0.8 (1.1)	1.4 (1.3)
Drought	53.7	57.3	3.1 (1.7)	3.2 (1.6)	2.3 (0.8)	2.3 (0.8)	0.2 (0.5)	1.3 (1.3)
Heavy rainfall	35.4	18.7	3.3 (1.8)	2.8 (1.6)	2.2 (0.9)	1.7 (1.2)	1.1 (1.1)	1.2 (1.3)
Erosion	5.0	1.7	2.9 (1.8)	2.6 (1.8)	2.2 (0.9)	1.9 (1.0)	1.1 (1.1)	2.0 (1.1)
Storm	54.9	26.7	4.2 (1.7)	2.9 (1.8)	2.1 (0.9)	1.8 (1.2)	1.8 (1.1)	1.6 (1.3)
Snow/ice rain	7.5	11.5	3.4 (1.5)	2.7 (1.7)	2.0 (1.0)	1.1 (1.2)	0.9 (0.9)	1.0 (1.2)
Biological	**75.2**	**44.1**	**5.7 (3.2)**	**2.5 (3.8)**	**2.3 (0.8)**	**1.8 (0.9)**	**0.3 (0.7)**	**1.2 (1.1)**
Crop pest	65.6	37.1	4.0 (1.7)	3.8 (1.7)	2.3 (0.8)	2.0 (0.9)	0.2 (0.5)	1.1 (1.2)
Storage pest	7.0	15.9	2.5 (1.9)	4.3 (1.6)	1.8 (0.8)	1.6 (1.0)	0.1 (0.3)	1.3 (1.1)
Livestock disease	48.8	14.1	3.0 (1.6)	3.1 (1.9)	2.2 (0.9)	1.7 (1.0)	0.4 (0.9)	1.4 (1.1)
Socio-demographic	**85.5**	**89.0**	**5.5 (3.4)**	**4.7 (3.9)**	**1.8 (0.9)**	**1.8 (0.9)**	**0.7 (0.9)**	**1.0 (1.1)**
Illness	98.5	78.6	3.4 (1.8)	3.1 (1.9)	2.0 (0.9)	2.0 (1.0)	0.4 (0.9)	1.0 (1.2)
Death	0.2	7.9	1.5 (1.0)	2.3 (2.3)	1.0 (0.8)	1.0 (1.0)	0.0 (0.0)	1.0 (1.0)
Household dynamics	35.0	29.4	1.7 (0.9)	1.5 (0.8)	1.4 (1.1)	1.1 (1.1)	0.3 (0.7)	0.6 (1.0)
Household ceremony	29.3	34.1	3.7 (2.1)	1.6 (1.4)	1.3 (1.1)	2.0 (1.0)	0.3 (0.8)	1.3 (1.3)
Household damage	20.3	10.9	1.6 (1.2)	1.7 (1.5)	1.8 (1.2)	1.9 (1.2)	2.4 (0.9)	2.0 (1.1)
Theft	6.3	7.8	2.7 (1.8)	2.0 (1.7)	1.6 (1.0)	1.5 (1.3)	1.6 (1.0)	1.9 (1.1)
Accident	5.9	32.6	1.2 (0.7)	1.9 (1.6)	2.6 (0.7)	2.2 (1.0)	2.6 (0.9)	1.3 (1.3)
Neighbour conflict	-	3.0	- -	2.2 (1.8)	- -	0.8 (1.1)	- -	0.7 (1.1)
Law suit	-	3.6	- -	1.4 (1.2)	- -	2.3 (1.0)	- -	1.9 (1.3)
Was cheated	-	4.7	- -	2.3 (1.7)	- -	2.3 (0.9)	- -	1.5 (1.3)
Economic	**41.3**	**69.5**	**5.0 (3.1)**	**4.5 (4.5)**	**2.2 (0.8)**	**2.5 (0.7)**	**0.4 (0.9)**	**1.2 (1.2)**
Remittances stop	-	6.1	- -	3.0 (2.1)	- -	2.2 (1.0)	- -	1.1 (1.3)
Collapse of business	1.9	14.0	2.0 (1.4)	2.3 (1.9)	2.7 (0.6)	2.5 (0.8)	0.9 (1.1)	1.4 (1.3)
Rise of interest rates	15.8	12.6	2.1 (1.0)	2.7 (1.8)	2.4 (0.8)	2.2 (1.0)	0.1 (0.4)	1.6 (1.3)
Fall in output prices	8.8	22.1	2.3 (1.5)	3.4 (1.8)	2.6 (0.6)	2.4 (0.8)	0.2 (0.6)	1.5 (1.3)
Rise in input prices	33.5	58.0	3.4 (1.7)	4.5 (1.4)	2.2 (0.8)	2.5 (0.8)	0.4 (0.9)	1.2 (1.3)
Market regulations	8.8	7.8	3.4 (1.6)	4.3 (1.8)	1.7 (0.8)	2.2 (0.8)	0.1 (0.5)	1.5 (1.1)

Source: DFGFOR756 base survey.

Note: [1] Complete sample of households with at least 1 nucleus member which were interviewed in both survey waves. Expected number of risk and risk severity were computed exclusively for households perceiving the respective risk type. Standard errors are presented in brackets. [2] Risk severity measured as ordinal scale from 0 (=no impact) to 3 (=high severity).

The majority of households expect to be affected by climate risks especially drought, flooding and storm (90% in Vietnam, 73% in Thailand) followed by socio-demographic risks, i.e. mainly illnesses of household members (98.5% in Vietnam, 78.6% in Thailand). Almost 70% of Thai households fear that economic risks such as rising in production input prices and falling in output prices will affect them

comparing to a smaller but still considerable share of 41% of Vietnamese households. On the other hand, three-quarter of Vietnamese households anticipate biological risks especially crop pest and livestock diseases compared to 44% in Thailand.

This discrepancy between shock experience and risk perception can be explained by various theories which address the dynamic process of risk perception formation, including (social) learning theory and prospect theory (Kahnemann and Tversky 1979, Rogers 1997). In general, there is a range of different factors that in addition to direct experience impact on individuals' perception of risk. Learning theory addresses the process through which direct experience of events is translated into personal perception. Factors in that process include "exposure, attention, acceptance, retrieval of information, beliefs and attitudes to execution of behavior" (Bandura 1986). Prospect theory focuses on the relationship between stimulus and response in the formation of risk perception (Rogers 1997).

In both countries the expected frequency of risks is highest for climatic events, especially flooding and storm in Vietnam as well as flooding and drought in Thailand. In terms of expected severity, households in both countries expected the adverse effects of risks to be higher on income than on assets, particularly severity on income from climatic and economic risks.

Although the majority of households anticipate climate risk to occur in the next 5 years, a comparatively small share of households applied various ex-ante risk management strategies in order to prevent the adverse effects of future climate shocks (Table 5.3). Overall, about one third of Vietnamese households and 20% of Thai households applied at least one ex-ante coping strategy. In both countries, two major strategies stand out, both focusing on the physical prevention of damage. On the one hand about 13% of households in Vietnam and 8% in Thailand engaged in collective action in order to build infrastructure that can ameliorate the threat of climatic hazards. Such infrastructure includes, for instance, river dikes which help to prevent flood water from inundating agricultural land, and irrigation canals that maintain water provision to cropping systems during times of drought. Some households jointly manage common property resources, such as forests and lakes to ensure a sustainable extraction of natural resources. Collective action as a means to adapt to climate

change has become increasingly important in Vietnam where local-level hazard planning and defense systems, which had been previously provided by the state, were decentralized in the mid-1990s. For example, sea dikes, which until the mid-1990s were managed by agricultural cooperatives, have not been maintained anymore in many areas since the decollectivization of agriculture. It is argued that, particularly for marginalized groups, collective action will be a crucial means to maintain security in an increasingly risky natural environment (Adger 2003).

Table 5.3: Ex-ante copings for climate risk perceived in 2008

Type of coping strategy	Households (%)	
	VN	*TH*
Any coping strategy	**33.0**	**18.4**
Collective action	**13.7**	**8.2**
Collective action for infrastructure	12.5	8.1
Common property resource management	2.9	0.1
Investment activites	**11.9**	**3.9**
Investment in security of homestead	11.7	0.3
Investment in physical and human capital	0.2	3.5
Investment in travel safety	0.1	-
Income diversification	**3.8**	**2.7**
Crop, plot, livestock diversifiaction	1.7	0.8
Income source diversification	1.6	1.8
Switch to more secure income sources	0.6	0.1
Savings	**3.6**	**1.6**
Buffer stocks	3.2	1.3
Savings accounts in financial institutions	0.2	0.3
Membership in rotating savings and credit associations	0.1	-
Contract insurances	0.1	0.1
Old age annuities	0.1	-
Others	**6.2**	**1.6**
Migration	2.6	0.1
Sharecropper tenancy	0.6	-
Medical treatment	0.3	-
Membership in occupational organisations	0.1	-
Preventive health practices	0.1	0.1
Marriage and extended family	0.1	-
Not specified	2.7	1.5
N[1]	1932	1555

Source: DFGFOR756 base survey.
Note: [1] Households with at least 1 nucleus member which perceived climate risk.

On the other hand about 12% of the climate risk perceiving households in Vietnam and 4% in Thailand invested in the security of their own homestead as well as in

physical and human capital. Investments in homestead security, similar to collective action, focus on the physical prevention of adverse weather calamity effects including, for example, building elevated wooden platforms as a place of retreat when flood waters enter the house. Investment in physical and human capital extends the ability of households to equip their members with skills to deal with adverse effects of climate risk. In both countries, only a minor share of households diversified their income portfolio, built up savings (e.g. buffer stocks of food and seeds, savings accounts in financial institutions) or used alternative strategies such as migration.

5.3 Empirical model

A three-step regression approach is applied in order to identify possible linkages between past shock experience and future climate risk perception, and to clarify the role of climate risk perception in influencing households' decisions to apply ex-ante risk management strategies. In the first step households' risk perception is estimated while controlling for the short-term effect of climate-related shocks on households' risk perception as well as for other socio-demographic factors that are expected to construct and maintain risk expectations. The ordinary least squares (OLS) regression which is employed for that purpose takes the following form:

$$R_i = \lambda S_i^c + \phi X_i^r + \gamma P_p \qquad (1)$$

where i indexes household and R_i is an ordinal risk score which indicates the magnitude of climate risk which a household expects to happen in the future. In the household questionnaire respondents were asked to quantify both the expected frequency of each climate shock type which they expected to happen in a 5-year future reference period and the expected severity of each of these events. The expected severity was stated separately in terms of income and asset loss, and by using an ordinal scale from 0 (=no impact) to 3 (=high severity). The risk score is computed by summing up the expected severity of each risk event and then multiplying it with the expected frequency of the event. The sum of the risk scores of all expected climate shocks of a household is then R_i. Furthermore, S_i^c is a vector of climate shock incidents that a household experienced during 2002 and 2008 and X_i^r is a vector of socio-demographic characteristics of the interview respondent. P_p is a vector of dummy variables in order to capture the effect of provinces. λ, ϕ and γ are the parameters to be estimated.

The second step is to assess the probability to adopt any ex-ante risk mitigation action by applying a standard probit model,

$$\begin{aligned} Y_i^* &= \psi R_i + \phi X_i^h + \gamma P_p + u_i \\ Y_i &= 1 \quad if \quad Y_i^* > 0 \\ Y_i &= 0 \quad otherwise \end{aligned} \tag{2}$$

where *i* indexes household, Y_i^* is a latent decision variable, R_i is the ordinal risk score which was used as dependent variable in the first-step regression, X_i^h is a vector of socio-demographic household characteristics and P_p is a vector of dummy variables in order to capture the effect of provinces. Instead of observing Y_i^* a binary variable Y_i is observed which takes the value 1 if a household applies any ex-ante risk management strategy in order to cope with perceived climatic risk. ψ, ϕ and γ are the parameters to be estimated (Wooldridge 2002).

In the third step the likelihoods of households taking up the most frequently applied ex-ante risk management strategies are estimated. It is assumed that the decisions of households to engage in the different strategies are correlated. Therefore a standard probit model is not suitable for making predictions about the joint probabilities of the relevant risk management strategy choices. Instead a bivariate probit model is used for Vietnam which includes two strategies: collective action and investment activities. In Thailand a multivariate probit model is used to extend the choice of strategies to also include income diversification and savings. Consider the following stochastic functions, one for each risk management strategy choice from 1 to *J*.

$$\begin{aligned} Y_{1i}^* &= \psi_1 R_{1i} + \phi_1 X_{1i}^h + \gamma_1 P_{1p} + u_{1i} \\ Y_{1i} &= 1 \quad if \quad Y_{1i}^* > 0 \\ Y_{1i} &= 0 \quad otherwise \end{aligned} \tag{3}$$

$$\begin{aligned} Y_{2i}^* &= \psi_2 R_{2i} + \phi_2 X_{2i}^h + \gamma_2 P_{2p} + u_{2i} \\ Y_{2i} &= 1 \quad if \quad Y_{2i}^* > 0 \\ Y_{2i} &= 0 \quad otherwise \end{aligned} \tag{4}$$

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$$
\begin{aligned}
&Y_{Ji}^{*} = \psi_J R_{Ji} + \phi_J X_{Ji}^{h} + \gamma_J P_{Jp} + u_{Ji} \\
&Y_{Ji} = 1 \quad if \quad Y_{Ji}^{*} > 0 \\
&Y_{Ji} = 0 \quad otherwise
\end{aligned}
\tag{5}
$$

where the variable coefficients and parameters are specified as in the second-stage standard probit model. The bivariate and multivariate probit model hypothesizes that at least parts of these errors are correlated (Greene 2003) and is estimated by means of maximum likelihood methods.

5.4 Results

In the following the outcome of the econometric analysis is presented. Note that the number of observations included in the regression models is smaller than the initial sample size since some households have been excluded from the analysis in order to ensure the normal distribution of all variables. All models have been tested for multicollinearity between explanatory variables and no problematic collinear relationships could be detected. The regression estimates of the presented models are adjusted for heteroskedasticity. Testing for specification error by means of a link test indicated that no important independent variables have been omitted. Table 5.4 presents the descriptive statistics of those variables used in the OLS regression of climate risk perception.

Table 5.4: Descriptive statistics of OLS regression variables

	Vietnam		**Thailand**	
	Mean	Std. Dev.	Mean	Std. Dev.
Climate risk perception (Ordinal score)	21.80	21.76	18.07	16.38
Agricultural occupation (1=Yes)	0.80	0.40	0.80	0.40
Member in socio-political organization (1=Yes)	1.27	0.44	0.10	0.30
Age (Years)	47.43	14.10	50.67	13.03
Age squared (Years)	2448.80	1477.74	2737.38	1365.08
Ethnicity (1=Kinh)	0.85	0.36		
Education (Years)	6.88	3.79	5.25	3.04
Gender (1=Male)	1.46	0.50	0.43	0.49
Ha Tinh (1=Yes)	0.37	0.48	0.44	0.50
Dak Lak (1=Yes)	0.37	0.48	0.18	0.38
Weather shocks of high severity (Number)	0.71	0.81	0.60	0.81
Weather shocks of medium severity (Number)	0.26	0.52	0.30	0.59
Dak Lak * Weather shocks of high severity	0.33	0.67		

Source: DFGFOR756 base survey.
Note: Std. Err. = linearized standard error. n=1651 (Vietnam). n=1555 (Thailand).

Results of the OLS regression of climate risk perception are presented in Table 5.5. The reported F-test and R^2 indicate that the independent variables are jointly significant and that the model has a reasonable goodness of fit. Identical regression models were applied for both countries except that ethnicity and a multiplicative term have been added to the Vietnamese model in order to capture ethnic diversity and to interact highly severe climate shocks with the Dak Lak province dummy variable.

Results from both countries indicate that households which experienced more frequent adverse climate incidents during the last 7 years are more sensitive and pessimistic to future climate risk estimation than households which underwent fewer or no climate shocks, a finding similar to the outcome of Paul's (1984) study. The estimated effects of the constitutive terms of the interaction term must be interpreted with care as the effect of one constitutive term on the dependent variable is conditional upon the value of the other independent constitutive term (Wooldridge 2000). In Vietnam, climate shocks of high subjectively perceived severity are found to be significantly and positively correlated with the level of climate risk which households from provinces other than Dak Lak perceive. For households from Dak Lak province a similar positive effect is indicated after calculating the relevant marginal effect, however the size of the effect is comparatively small. This means that the climate risk perception of households from Dak Lak province increases to a smaller extent as a response to experiencing highly severe climate shocks. This may be due to the geographical location of Dak Lak in Vietnam's Central Highlands region that is less prone to cyclones and tropical storms than coastal provinces. Thus, households might see extreme climate conditions as rare events that are unlikely to occur again in the near future.

Results furthermore indicate that household respondents from Dak Lak province reveal a considerable and significant lower perception of climate risk than household from Thua Thien Hue province in the absence of highly severe climate shocks. No significant relationship can be identified with regards to climate shocks of lower subjectively perceived severity, which emphasizes the importance of differentiating between shock events of different severity levels.

Table 5.5: OLS regression of climate risk perception against socio-demographic characteristics

	Vietnam		Thailand	
	Coef.	t-value	Coef.	t-value
Agricultural occupation (1=Yes)	6.23	3.84 ***	2.47	2.62 ***
Member in socio-political organization (1=Yes)	4.38	3.65 ***	0.67	0.54
Age (Years)	0.39	2.27 **	-0.04	-0.12
Age squared (Years)	0.00	-2.42 **	0.00	-0.03
Ethnicity (1=Kinh)	0.75	0.66	-[a]	-[a]
Education (Years)	0.10	0.77	-0.10	-0.75
Gender (1=Male)	-1.51	-1.59	-0.26	-0.32
Buriram (TH) / Ha Tinh (VN) (1=Yes)	-1.68	-0.76	4.87	4.88 ***
Nakhon Panom (TH) / Dak Lak (VN) (1=Yes)	-18.90	-8.72 ***	2.44	2.00 **
Climate shocks of high severity (Number)	8.87	7.51 ***	5.19	7.29 ***
Climate shocks of medium severity (Number)	1.42	1.21	2.69	4.27 ***
Dak Lak * Climate shocks of high severity	-6.24	-4.88 ***	-[a]	-[a]
Constant	6.66	1.18	12.20	1.70 *
P > F (joint significance)	0.00		0.00	
R^2	0.28		0.10	
N	1651		1555	

Source: DFGFOR756 base survey.
Note: [a] Variables omitted. *P<0.1, **P<0.05, ***P<0.01.

Climate risk perception of Thai households is especially responsive to past climate shock experiences of both high and medium subjective severity. Moreover, households in the provinces of Buriram and Nakhon Panom generally perceive climate risk to be higher than households in the province of Ubon Ratchathani. This indicates possible differences in micro-climatic conditions and socio-cultural factors between provinces.

Further results show that agricultural occupation of the respondent in both countries increases the level of perceived climate risk. This suggests that household members who are actively engaged in agriculture are more aware of the hazards that climatic fluctuations can bring about, regardless of any actual climate shock experience. Furthermore, two other socio-demographic characteristics of respondents are found to have significant influence on climate risk perception in Vietnam. Membership in a socio-political organization, such as the Communist Party or the Veteran's Union, is indicated to be positively related with perceived climate risk. As social learning theory suggests, beliefs of individuals are not only shaped by self-experience but also by observing and retrieving information from others (Bandura 1971, Rotter 1954). Those Vietnamese farmers who have a larger personal network through which they can access information from both other farmers and governmental sources may perceive the risk of being affected by climatic adversities to be higher than farmers

who can only rely on their own experience. Moreover, older respondents are likely to evaluate a higher perception of climate risk which may be explained by an increasing preoccupation for their family and a more profound long-term experience of the effects of climate shocks. However, for respondents who are very old a declining climate risk perception is indicated.

Table 5.6: Descriptive statistics of standard and bivariate probit regression variables

	Vietnam		**Thailand**	
	Mean	Std. Err.	Mean	Std. Dev.
Ex-ante climate risk mitigation (1=Yes)	0.30	0.46	0.18	0.39
Collective action (1=Yes)	0.10	0.29	0.08	0.27
Investment (1=Yes)	0.13	0.34	0.04	0.19
Diversification (1=Yes)			0.03	0.16
Savings (1=Yes)			0.02	0.13
Maximum education (Years)	9.35	3.37	8.76	3.75
Wealth per capita (PPP$)			57348.97	63224.58
Tangible assets value (PPP$)	792.50	735.08		
Number of household members	4.32	1.70	4.10	1.74
Average monthly per capita income (PPP$)	24.37	27.52	182.38	401.32
Ethnicity of household head (1=Kinh)	0.85	0.36		
Engagement in off-farm employment (Months)	12.47	10.25	11.53	11.25
Farm size (ha)	0.07	0.06		
Age of household head (Years)	48.91	13.69	55.66	13.09
Age of household head squared (Years)	2579.63	1474.14	3268.18	1531.51
Engagement in agriculture (%)	0.73	0.38	0.50	0.29
Off-farm employment as main option (1=Yes)	0.43	0.50		
Climate risk score	24.39	21.60	18.07	16.38
Time to district town (Minutes)	33.40	21.32	22.18	12.59
Time to marktet (Minutes)	15.27	9.46	16.80	14.23
Buriram (TH) / Ha Tinh (VN) (1 = Yes)	0.37	0.48	0.44	0.50
Nakhon Panom (TH) / Dak Lak (VN) (1 = Yes)	0.37	0.48	0.18	0.38

Source: DFGFOR756 base survey.
Note: Std. Err. = linearized standard error. n=1476 (Vietnam). n=1555 (Thailand).

The descriptive statistics of those variables used in the standard and bivariate probit models of ex-ante risk management application are given in Table 5.6.

Table 5.7: Probit regression of household use of ex-ante climate risk management strategies in 2008 against socio-demographic characteristics

	Vietnam		Thailand	
	Coef.	dF/dx	Coef.	dF/dx
Maxiumum education (Years)	0.0023	0.0005	0.0167	0.0031
Wealth per capita (PPP$)	-[a]	-[a]	0.0000	0.0000
Tangible assets (PPP$)	0.0001	0.0000	-[a]	-[a]
Number of household members	0.0389	0.0085	-0.0130	0.0065
Average monthly per capita income (PPP$)	-0.0005	-0.0001	-0.0003 *	0.0000
Engagement in off-farm employment (Months)	-0.0087 *	-0.0019	0.0012	0.0009
Age of household head (Years)	0.0092	0.0020	-0.0250	0.0056
Age of household head squared (Years)	-0.0001	0.0000	0.0002	0.0000
Engagement in agriculture (%)	-[a]	-[a]	0.1474	0.0360
Land size (ha)	0.7966	0.1750	-[a]	-[a]
Ethnicity of household head (1=Kinh)	0.4618 *	0.0839	-[a]	-[a]
Climate risk score	0.0039 *	0.0009	0.0044 **	0.0006
Time to district town (Minutes)	0.0013	0.0003	-0.0001	0.0008
Time to market (Minutes)	-0.0042	-0.0009	-0.0056 *	0.0009
Off-farm employment as main option (1=Yes)	-0.1419	-0.0308	-[a]	-[a]
Buriram (TH) / Ha Tinh (VN) (1 = Yes)	0.0782	0.0173	-0.1019	0.0257
Nakhon Panom (TH) / Dak Lak (VN) (1 = Yes)	-2.3375 **	-0.4282	0.3046 **	0.0331
Constant	-0.9082		-0.2373	
P > F (Wald test)	0.0000		0.0001	
N	1476		1555	

Source: DFGFOR756 base survey.
Note: [a] Country-specific omitted variable. *P<0.1, **P<0.05, ***P<0.01. dF/dx indicates the marginal effect of a one-unit change in the explanatory variable on the probability to use any ex-ante climate risk management strategies.

Table 5.7 shows the results of the probit regression of households' application of any ex-ante climate risk management strategies in 2008. Note that the explanatory variables vary slightly to reflect the country-specific situations. In addition to the income indicator for Thailand, wealth is an asset-based indicator reflecting aggregate value of productive and consumption assets, house, owned land, livestock and savings. In Vietnam, on the other hand, tangible assets and land size are separated since land is more difficult to sell or buy due to the political frame conditions. The value of land is therefore difficult to estimate and land size is used as a reasonable proxy for land value. Furthermore, although the majority of households rely on agriculture as main income source, simultaneous off-farm and/or non-farm employment are common among Thai households. Hence, "off-farm employment as main option" village variable is replaced with ratio of "engagement in agriculture" household characteristic.

The outcome indicates that in both countries the degree of climate risk perception is significantly increasing the probability of households to use any ex-ante climate risk

management strategy, although the magnitude of this effect is relatively small. More importantly, location characteristics in Vietnam are significantly decreasing the likelihood of applying ex-ante climate risk management strategies, with households living in Dak Lak province revealing a probability that is about 43% lower than in the province of Thua Thien Hue.

In Vietnam, additional covariates which have a significant effect on households' decision to use ex-ante climate risk management strategies are the ethnicity of the household head and the engagement of the household in off-farm wage- or non-farm self-employment. Belonging to Vietnam's ethnic Kinh majority increases the probability of applying these strategies by about 8% which might suggest that ethnic minorities have a relatively poor access to the knowledge and resources required to apply risk mitigation techniques. On the contrary, income source diversification, i.e. being engaged for more months in off-farm wage- or non-farm self-employment, lowers the likelihood of ex-ante climate risk management strategy use, indicating that such households depend on their agricultural production to a smaller extent and can still count on their non-agricultural income sources when weather calamities damage their crops or livestock (Phung Duc and Waibel 2010a).

In Thailand, the decision to adopt ex-ante mitigation strategies is significantly and negatively influenced by household income level and travel time to market. This suggests that higher-income households and those living closer to a market are less likely to apply precautionary measures against climate risks, however the marginal effect is rather small. Moreover, households in the provinces of Ubon Ratchathani and Buriram are more likely to take up ex-ante risk mitigation actions than households in Nakhon Panom province.

The outcome of the bivariate probit regressions of Vietnamese households' use of collective action and investment activities as ex-ante climate risk management strategies are shown in Table 5.8. Results indicate that a higher climate risk score is significantly increasing the probability that households engage in collective action for infrastructure, such as dikes and irrigation canals, in order to reduce their vulnerability to climate risk, while no significant relationship is suggested with respect to investment in homestead security, including for example structural reinforcements of

buildings to make them more resistant to storm damage. The reasons for this difference might be that collective action can be organized more spontaneously when the risk perception level of a group of households is high, requiring mainly labor input from the household side, whereas investment in homestead security depends more on long-term strategic decisions of households which often have a limited ability to invest due to financial constraints.

Table 5.8: Bivariate probit regressions of Vietnamese household use of collective action for infrastructure and investment in homestead security as ex-ante climate risk management strategies against socio-demographic characteristics

	Collective action		**Investment activities**	
	Coef.	dF/dx	Coef.	dF/dx
Maximum education (Years)	0.0014	0.0001	0.0186	0.0000
Tangible assets value (PPP$)	0.0004 ***	0.0000	-0.0002 *	0.0000
Number of household members	0.0543	0.0034	-0.0376	0.0000
Average monthly per capita income (PPP$)	-0.0008	-0.0001	-0.0014	0.0000
Ethnicity of household head (1=Kinh)	0.2987	0.0154	0.4713	0.0003
Off-farm employment (Months)	-0.0095	-0.0006	0.0025	0.0000
Land size (ha)	-2.7192	-0.1712	2.1668 **	0.0024
Age of household head (Years)	-0.0060	-0.0004	0.0115	0.0000
Age of household head squared (Years)	0.0000	0.0000	-0.0002	0.0000
Climate risk score	0.0102 ***	0.0006	-0.0012	0.0000
Off-farm employment = main option (1=Yes)	-0.3974	-0.0240	0.2191	0.0003
Time to district town (Minutes)	-0.0012	-0.0001	0.0036	0.0000
Time to marktet (Minutes)	0.0055	0.0003	-0.0010	0.0000
Ha Tinh dummy (1=Yes)	0.1903	0.0125	0.4731 ***	0.0007
Dak Lak dummy (1=Yes)	-1.5047 ***	-0.0903	-6.1764 ***	-0.1632
Constant	-1.7788		-1.8934	
P > F (Wald test) = 0.0000				
Rho (ρ) = -0.2637061***				

Source: DFGFOR756 base survey.

Note: *P<0.1, **P<0.05, ***P<0.01. dF/dx indicates the marginal effect of a one-unit change in the explanatory variable on the probability to use collective action for infrastructure and investment in homestead security, respectively, as ex-ante climate risk management strategy. n=1476.

Again, location factors play a key role in determining the adoption of these main ex-ante climate risk management strategies. In Dak Lak, households are significantly less likely to apply either of the two strategies as compared to households in Thua Thien Hue. In Ha Tinh, however, investment activities are significantly more likely than in Thua Thien Hue. A possible explanation for these findings is a difference in the

promotion of risk management behavior between Vietnamese provinces that may cause such distinct adoption of ex-ante strategies.

The estimates of the effect of the value of all tangible assets which a household possesses on the application of the most frequently applied ex-ante climate risk management strategies yield contrary signs. Tangible asset value is significantly positively related to the engagement in collective action, an expected outcome since a household with more valuable tangible assets should have a higher incentive to protect its assets by applying ex-ante climate risk management strategies. However, a significant negative relationship is indicated between tangible asset value and investment in homestead security. In fact, households might possess highly valuable tangible assets as a consequence of already having invested in the security of their homestead in the past. Thus there would be a much smaller need for such households to further invest. On the contrary, investment in homestead is significantly positively correlated with farm size, a possible indicator for the extent of wealth that needs to be protected from climate risk..

For Thai households, Table 5.9 summarizes the results of the estimated multivariate probit model. The outcome reveals specific relationships between the same set of variables from the previous probit model and the adoption probability of four major ex-ante mitigation activities, i.e. collective action, investment activities, income diversification and savings. The results indicate that, on the one hand, the effect of climate risk perception on collective action for infrastructure and common property resource management as well as on individual household income diversification is positive and significant. Households which perceive climate risk to be threatening are more likely to get together and form a joint cooperation within the village to protect and preserve common infrastructure and natural resources. Moreover, they are more likely to diversify agricultural portfolio and income sources to cushion negative effects of risks on income and asset. On the other hand, a positive, but not significant, relationship between climate risk perception and investment, as well as between climate risk perception and savings is indicated. High risk perception may not immediately prompt for investment and savings accumulation as households may be short of financial capital.

Furthermore, reliance on agriculture as main occupation increases the likelihood that a household would invest in physical and human capital as well as security of homestead. Off-farm employment, on the contrary, increases the probability that a household would build up savings from additional income sources. Village and province characteristics also play a role in making a choice of which ex-ante mitigation strategy to apply. Closer distance to district town significantly encourages diversification of income sources due to greater possibility to find off-farm and non-farm employment. Furthermore, households living in Ubon Ratchathani are more likely to join collective action and to invest than in other provinces while households living in Buriram and Nakhon Panom are more likely to diversify income sources and build up savings.

Table 5.9: Multivariate probit regressions of Thai household use of major ex-ante climate risk management strategies against socio-demographic characteristics

	Collective action		Investment		Diversification		Savings	
	Coef.	**dF/dx**	**Coef.**	**dF/dx**	**Coef.**	**dF/dx**	**Coef.**	**dF/dx**
Maximum education (Years)	0.0155	0.0022	0.0246	0.0019	-0.0126	-0.0007	0.0100	0.0004
Wealth per capita (PPP$)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Number of household members	0.0274	0.0039	-0.0097	-0.0008	-0.0150	-0.0008	-0.0211	-0.0008
Average monthly per capita income (PPP$)	-0.0001	0.0000	-0.0004	0.0000	-0.0003	0.0000	-0.0003	0.0000
Engagement in agriculture (%)	0.2694	0.0385	0.5577 ***	0.0441	0.0235	0.0013	-0.5781 *	-0.0214
Off-farm employment (Months)	0.0004	0.0001	-0.0022	-0.0002	0.0027	0.0001	-0.0241 ***	-0.0009
Age of household head (Years)	-0.0236	-0.0034	-0.0243	-0.0019	-0.0444	-0.0025	0.0296	0.0011
Age of household head squared (Years)	0.0002	0.0000	0.0002	0.0000	0.0004	0.0000	-0.0004	0.0000
Climate risk score	0.0064 **	0.0009	0.0013	0.0001	0.0124 ***	0.0007	0.0023	0.0001
Time to district town (Minutes)	0.0015	0.0002	0.0049	0.0004	-0.0160 **	-0.0009	-0.0041	-0.0002
Time to market (Minutes)	-0.0042	-0.0006	-0.0057	-0.0004	0.0020	0.0001	-0.0109	-0.0004
Buriram dummy (1 = Yes)	-0.3653 ***	-0.0523	-0.5045 ***	-0.0399	0.7971 ***	0.0448	0.3628	0.0134
Nakhon Panom dummy (1 = Yes)	0.0160	0.0023	-0.0512	-0.0040	0.7681 ***	0.0432	0.7226 ***	0.0268
Constant	-1.0236		-1.2941		-1.1412		-2.2781 *	
/atrho21	-0.1015	rho21	-0.1011					
/atrho31	0.0593	rho31	0.0592					
/atrho41	-0.0184	rho41	-0.0184					
/atrho32	-0.1293	rho32	-0.1286					
/atrho42	-0.3362	rho42	-0.3241					
/atrho43	-0.0011	rho43	-0.0011					

Source: DFGFOR756 base survey. Note: Likelihood ratio test of rho21 = rho31 = rho41 = rho32 = rho42 = rho43 = 0: chi2(6) = 1.0e+06 Prob > chi2 = 0.0000. n=1530. Wald chi2(52) = 168.87. Log pseudolikelihood = -507075.72.

5.5 Summary, conclusions and recommendations

The empirical findings from six provinces in Central Vietnam and Northeastern Thailand provide some important insights into the relationship between shock experience, risk perception and the use of ex-ante risk management strategies with regards to climate risk among rural households. Concerning the status of climate shock experience between 2002 and 2008, risk perception anticipated for the next 5 years and ex-ante risk management currently applied (research question 1), it is indicated that households in both countries are affected by different types of shocks among which climate calamities rank highest followed by socio-demographic shocks, mainly illnesses of household members. Furthermore, a large share of households in Thailand suffer from economic shocks especially price fluctuations of production inputs and outputs, whereas Vietnamese households are more prone to biological shocks, such as crop pests and livestock diseases. On average households in both countries experienced two climate shocks between 2002 and 2008 with Vietnamese households reporting a higher average subjective severity.

Compared to the observed shock experience households appear to be relatively pessimistic with regards to their perception of respective future risk as both the share of households expecting future shocks and the variety of shock types expected is larger. This points to the existence of factors other than short- and medium-term shock experience which are additional determinants of climate risk perception. In both countries the expected frequency and severity of risks is highest for climatic events. In terms of expected severity, households in both countries expected the adverse effects of risks to be higher on income than on assets. The main ex-ante climate risk management strategies which rural households in the study areas apply are 1) engagement in collective action to build infrastructure and manage common property resource, 2) investment in homestead security as well as physical and human capital, 3) income source diversification and 4) savings accumulation. In general only about one third of Vietnamese and 18% of Thai households applied respective precautionary measures.

Referring to the link between climate shock experience and risk perception (research question 2), the experience of climate shocks of high (both countries) and medium

(Thailand) subjective severity increased climate risk perception of households while other factors, in particular agricultural occupation of the respondent and location (both countries), are also identified as significant determinants. Regarding the effect of climate risk perception on the use of any (research question 3) and specific main (research question 4) ex-ante climate risk management strategies, it can be shown that although a positive relationship is indicated in the former case, the latter case shows an ambiguous outcome. The likelihood of the decision that a household would engage in collective action (both countries), investment activities (Vietnam) and income source diversification (Thailand) increases with rising risk perception while no such link is indicated with regards to the decision to investment and savings. Again, further determinants of adoption can be identified among which location factors stand out as the most important ones in Vietnam while the degree of agricultural engagement and off-farm occupation of household members are the significant factors in Thailand.

Since the collection and processing of risk information is, among other strategies, a key risk management activity (Noell and Odening 1997), governmental risk communication campaigns and traditional early warning systems that focus on informing rural households about potential hazards are important tools to help households navigating in a complex and uncertain world (Legesse 2002). Rural households in the study areas are able to translate their experience of climate shocks into climate risk perception, suggesting that they are to a considerable extent aware of those climatic hazards that are common in their regions. Risk communication processes between disaster management institutions and rural households thus can build on such knowledge. However, differences in the translation of risk experience into risk perception with regards to weather-related hazards suggest that people who are living in Dak Lak province; Vietnam, adjust their risk perception to a smaller extent as compared to people from Thua Thien Hue province, Vietnam. This points to differences in the awareness of households between provinces. Households living in certain provinces, such as Dak Lak, may underestimate the real risk of becoming adversely affected by extreme weather events, and therefore engage less in building capacity and preparing measures that can help to minimize disaster loss. Policy makers should take such inter-provincial differences into consideration when designing future risk information campaigns, as they may be due to differences in the success of past risk communication campaigns. The findings of this study call for

further investigations into the risk information competence of rural Vietnamese households.

The behavioral response of households is limited to four major ex-ante risk management strategies. The use of these main strategies depends on the level of climate risk perception as well as other determinants, most importantly location factors in the case of Vietnam which may reflect inter-provincial differences in the promotion of climate risk management and the respective knowledge of households, and engagement in agriculture and off-farm employment in the case of Thailand. The low share of farm households using alternative ex-ante risk mitigation options, particularly functional adjustments such as agricultural and non-agricultural income diversification, points to a possible existence of entry barriers to such strategies. Again further studies are required in this context, in order to pinpoint respective problems and find ways to eliminate such entry barriers.

Overall, this study provides a starting point for climate risk perception and ex-ante climate risk mitigation analysis focusing on small-scale rural households. As a further step in the analysis, the effect of ex-ante climate risk mitigation on the vulnerability to poverty of households may be estimated. Linking climate risk to poverty will allow drawing conclusions on the welfare implication of climate risk perception and facilitate the design of social risk management policies specifically tailored to vulnerable parts of the population.

Chapter 6

Synthesis

The objective of this thesis is to clarify some of the determinants of vulnerability to poverty among rural households in Vietnam. Hereby special emphasis is given to a particular agro-ecological zone namely the mountainous upland in three provinces of the Central Highlands and North Central Coast, namely Dak Lak, Ha Tinh and Thua Thien Hue, where the data have been collected. The thesis is presented as a series of three papers which are described in separate chapters. While chapters 3 and 4 focus exclusively on Vietnam, chapter 5 brings in a comparison with rural households in Thailand through which additional conclusions can be drawn. This chapter presents a synthesis of the three chapters, establishes some linkages among them and draws some overall conclusions and recommendations relevant for policy and future research.

6.1 Key findings and conclusions

This section presents in brief the key findings of chapters 3-5 and the conclusions that can be drawn with regards to the specific research objectives introduced in chapter 1. The first objective was addressed in chapter 3 entitled “Forest extraction as a response to shocks”.

To assess the role of using forest extraction as a coping strategy for rural households which are suffering from the negative effects of different types of shocks.

Chapter 3 analyzes households’ engagement in forest extraction as a response to two types of shocks, namely covariate weather shocks and idiosyncratic health shocks, which are examples of sources of vulnerability for a specific group of households in Vietnam. The outcome of this analysis indicates that rural households in the

mountainous upland of Vietnam use forest products as a "natural insurance" when being affected by certain types of shocks. Households in the mountainous upland of Thua Thien Hue province, Vietnam, mainly collect and log fuel wood in order to meet their own energy demands while additionally extracting non-fuel wood timber and NTFPs. Two types of shocks stand out as the most relevant in the study area: weather calamities, such as floods, storms, droughts and unusually cold weather, one the one hand and human health shocks on the other hand. Results suggest that households extract forest products as response to highly severe weather shocks whereas no such relationship is indicated with regards to human health shocks. Forest extraction is used as one high ranking coping mechanism among a range of various other strategies.

Household activities that aim at managing risk before shocks occur or coping with shocks after a shock has occurred, sometimes conflict with other societal objectives as it can be observed in the context of forest resources. The protection of public goods that forests provide, such as biodiversity and climate regulation, ranks high on the agenda of policy makers in times of global climate change and species loss. However, results of chapter 3 show that forest extraction is an important risk management and shock coping strategy in mountainous parts of rural Vietnam. Excluding local people from forests in order to protect public goods would impose further difficulties to households in their quest to smooth their consumption in times of hardship and may ultimately leave them more vulnerable to poverty. Examples from other parts of the world, like for example the Brazilian Amazon, have shown that locals have strongly defended their access to forest resources in situation when free access was being questioned (Allegretti 1990, Schwartzman et al. 2000).

The second objective was addressed in chapter 4 entitled "Impact of price shocks on typical farm households".

To develop a normative approach to vulnerability assessment by means of mathematical programming that can be used to test alternative methodologies for assessing whether a change in underlying frame conditions, triggered by a rise in prices of agricultural inputs and outputs, changes the activity portfolio and the vulnerability level of typical farm households

Chapter 4 assesses the effects of a price hike of food commodities and agricultural input factors, which is another example of a shock that can affect certain types of households in Vietnam, on production portfolio decisions of typical farm households in the mountainous upland of Thua Thien Hue province and their vulnerability to poverty. Against the background of the recent global price hike that arrived at its peak in 2008, this potential source of vulnerability is of particular relevance for farm households in different parts of the world including Vietnam. Unlike weather-related and health shocks, price fluctuations may even generate positive effects to some types of households. Albeit dominant negative consequences, collecting price data during the recent global price hike provided a rare opportunity to assess potential positive effects. The mathematical programming model applied analyses whether and how households adjust their income-generating activity portfolio, accounting for crop and livestock production as well as activities in natural resource extraction. Using mathematical programming in vulnerability analysis was done in order to test whether such normative models can serve as a suitable alternative to more common econometric models. The specific group of typical households examined faces a range of typical options and restrictions with regards to their income-generating activities, such as being small-holder farm households with a focus on crop production and additional activities in forest extraction and, to a minor extent, livestock husbandry. Agricultural production is labor-intensive due to a lack of access to machinery and households are frequently affected by weather shocks. Although market shocks are relatively rare events, the recent increase in the prices of agricultural inputs and outputs, especially of rice and fertilizer, has been transmitted to these households.

Results of the Target MOTAD mathematical programming model suggest a risk-efficient crop portfolio which, however, is only found to be feasible up to a certain level of risk-aversion. Only typical households with a relatively low level of risk aversion, meaning that they accept a certain level of shortfall from the required minimum level of income, are able to implement a risk-efficient production portfolio. This outcome is in line with the finding that households are vulnerable to poverty as they are expected to be below the poverty line in certain states of weather shock occurrence. Being confronted with higher input and output prices as observed in 2008, households adjust their crop portfolio by substituting rice with banana production. Concerning the probability to be poor in the future, the model outcome indicates that

the net-effect of the price hike on income is negative. The vulnerability level of households rises from 29% in 2007 to 100% in 2008. On the one hand, that is due to the increased consumer prices of rice that households need to pay. On the other hand, they are not able to benefit from higher producer prices of rice, since no market exists for selling their produce, while suffering from increased costs of production as a result of higher prices of chemical fertilizers. This finding confirms the outcome of previous studies (Headey and Fan 2008) which suggest that the consequences of price increases depend, among other factors, on the type of households, i.e. whether affected households are net food buyers or net food sellers. Thus, the type of household plays a key role when identifying parts of the population who are in immediate need of protection from price shocks.

The third objective was addressed in chapter 5 entitled "Climate risk perception and ex-ante mitigation strategies".

To explore whether past climate shock experience shapes the perception of climate risk, and how such perception affects the use of ex-ante risk management strategies.

Chapter 5 analyzes the linkage between climate shock experience, risk perception and ex-ante mitigation behavior by applying a three-step regression approach in a cross-country analysis comparing rural households in Vietnam and Thailand. The comparison with data collected in Thailand is adding value to the assessment for Vietnam because it can serve as a counterfactual. Similar to chapter 3, the analysis focuses on weather-related shocks, while relating their effects to ex-ante risk management rather than to ex-post coping. In both countries, rural households are affected by the same types of adverse events which can be categorized into different types including climate, biological, socio-demographic and economic shocks. Climate shocks rank highest in both countries and are defined as weather calamities, such as heavy rainfall, floods, storms, droughts, erosion and unusually cold weather, which have been identified as a consequence of the volatility of time-varying weather conditions with regards to frequency and severity. However, given the observed short- and medium term climate shock experience, households are comparatively pessimistic with regards to their perception of future risk of the same type as the percentage of households perceiving respective risk is higher than the share of households that have

experienced such shocks, and because the variation of expected shocks is higher than those of experienced events. Thus, further factors other than short- and medium term climate shock experience are presumed to affect individual risk perception. In fact, the econometric analysis shows that in addition to the positive and significant relationship between past experience of weather shocks and climate risk perception that is indicated, additional factors are found to influence risk perception, most importantly involvement in farm work and location factors in both countries.

With regards to the relationship between climate risk perception and ex-ante risk management it can be shown that the use of at least one ex-ante strategy for mitigating climate risk is significantly and positively related to respective risk perception in Vietnam and Thailand. However, when testing for the causal relationship between climate risk perception and several specific mitigation actions, ambiguous results are found. In the case of Vietnam, a significant positive relationship is indicated with collective action, such as for example building river dikes which help to prevent flood water from inundating agricultural land, and investment activities. In the case of Thailand collective action and income source diversification are significantly and positively affected by climate risk perception. For both countries, no significant relationship with the accumulation of savings was found. Additional determinants of the adoption of ex-ante climate risk management have been identified, most importantly location factors in Vietnam and the degree of agricultural and off-farm occupation in Thailand.

6.2 Policy implications

The results of the three papers which are actually case studies for a better understanding of the factors that can make rural households in developing countries and in particular in emerging market economies vulnerable to poverty allow drawing some conclusions which are believed to be of relevance for policy. Overall, the findings of this study show that vulnerability to poverty represents an issue of importance in rural Vietnam, thus confirming the outcome of previous investigations (World Bank 2003, World Bank 2008a), and possibly in similar emerging market economies. Therefore, poverty reduction strategies and programs need to take into account not only the needs of currently poor households but also of those at risk to be

poor in the future. In general, this entails the strengthening of households' ability to apply both effective ex-ante risk management as well as ex-post shock coping strategies. Since the sources of vulnerability among rural households in Vietnam are manifold, a set of measures aimed at improving risk management and shock coping abilities of households is needed.

The outcome of chapter 3 suggests that there is a need for suitable government interventions that can help to achieve a balance which on the one hand leaves vulnerable parts of the population living on the forest margin the opportunity to generate income from forest extraction in times of hardship, and on the other hand enables a sustainable management of natural resources. Recently introduced forest access control approaches suggest a growing awareness of this topic among Vietnamese policy makers. Changes of the land law which have been enacted in 2004 allow for the allocation of land (including forest) to communities, hence facilitating community forestry as a means to provide access to forest products to vulnerable households while at the same time aiming for a sustainable management of the resource (Sunderlin and Ba 2005). While the ongoing unsustainable degradation of forest lands in Vietnam suggests that simple prohibitions of extraction have been proven ineffective, such recently introduced forest access control schemes, which delegate both the extraction and protection of forest resources directly to the households, appear to be more promising. These approaches should be further strengthened in Vietnam as there is preliminary evidence they can lead to an improved management of natural resources (Nguyen Hai Nam 2002).

The results of chapter 4 show that, given high levels of risk aversion, typical farm households in the mountainous upland of Thue Thien Hue province are found to be unable to implement a risk-efficient crop portfolio. Several possible constraints are disclosed that households face in their agricultural production such as a limited endowment with agricultural land, missing access to certain input factors, such as machinery and organic fertilizer, as well as missing realistic alternative options to generate income such as other crop or livestock products or the engagement in off-farm wage labor and non-farm self-employment. Further investigation is needed here in order to better understanding the exact nature and underlying causes of such entry-barriers to effective risk management and shock coping in order to guide possible

policy interventions which can help to overcome such impediments to efficient risk-mitigation behavior.

Since the collection and processing of risk information is, among other strategies, a key risk management activity (Noell and Odening 1997), governmental risk communication campaigns and traditional early warning systems that focus on informing rural households about potential hazards are important tools to help households navigating in a complex and uncertain world (Legesse 2002). Risk communication campaigns may include, for instance, training courses for rural households to disseminate information on climate change and potential extreme events, or the creation of networks that can help to communicate weather forecasts to farmers. Results of chapter 5 indicate that such campaigns can build on a general awareness of rural households in Vietnam and Thailand about prevalent risk types. However, differences in the translation of risk experience into risk perception with regards to weather-related hazards suggest that people who are living in Dak Lak province; Vietnam, adjust their risk perception to a smaller extent as compared to people from Thua Thien Hue province, Vietnam. This finding points to differences in the awareness of households between provinces. Households living in certain provinces, such as Dak Lak, may underestimate the real risk of becoming adversely affected by extreme weather events, and therefore engage less in building capacity and preparing measures that can help to minimize disaster loss. Policy makers should take such inter-provincial differences into consideration when designing future risk information campaigns, as they may be due to differences in the success of past risk communication campaigns. The findings of this study call for further investigations into the risk information competence of rural Vietnamese households.

In addition to a sound knowledge about potential hazards, several further requirements need to be met in order to give households the ability to effectively apply those risk management strategies that are suitable to reduce their vulnerability to poverty. Chapter 5 indicates that in the case of climate risk more than half of all households in both Vietnam and Thailand do not actively respond to subjectively perceived threats, points to the existence of entry-barriers to suitable activities. Such limitations call for policy interventions which can help these households to overcome their impediments to risk-efficient behavior.

6.3 General conclusions and scope for further research

In addition to the conclusions and policy implications that can be drawn from the preceding chapters, this thesis also contributes methodologically to current research. It contributes an intuitive theoretical framework for the analysis of the effect of different types of adverse shocks, namely covariate weather shocks and idiosyncratic health shocks, on forest labor supply of households which is based on existing elements of new home economics theory. In testing the research hypothesis derived from this theoretical framework, the geographical scope of this analysis is extended to upland farm households in a Southeast-Asian context. The empirical analysis of forest extraction as a response to shocks may be advanced by adding further variables to the model which can better capture household-specific access to forest, including the distance from the homestead to the forest and the quality of the accessible forest resources.

Moreover, this thesis demonstrates that normative mathematical programming models of typical farm households have the advantage to simultaneously account for multiple sources of risk, such as price fluctuations and weather calamities, in a theoretically consistent framework. Although the behavioral assumptions entered in the model can be questioned, the incorporation of risk through the Target MOTAD approach is a valid representation of the degree of risk aversion. The flexibility of constructing typical households provides a direct way to assess individual vulnerability levels for a multitude of household types regardless of their total share on population size. Hence, conclusions can be drawn for vulnerability reduction policies of smaller administrative units which would be difficult with the use of positive econometric methods due to the problem of small sample sizes. It is, therefore, suggested to apply such approaches more often in future vulnerability analyses in order to complement more common econometric methods. In doing so, further improvements of the methodology are necessary. Different types of households both within and across countries could be analyzed in order to assess possible differences in shock response due to differences in resource endowments, marketing opportunities, agro-ecological frame conditions and even ethnicity-based patterns of behavior. Alternative options for generating income may be integrated into the models while taking into account fixed (investment) and variable costs of switching from one activity to another. In

general, it is strongly suggested to extend the model in order to capture multiple periods. A recursive structure could then account for interdependencies between actions and outcomes in different periods. The risk-module of the model could be extended in order to capture the effects of further types of shocks, such as idiosyncratic health shocks and biological shocks.

Concerning the analysis of ex-ante risk management in response to climate risk perception and experience, this thesis provides a contribution to the relative sparse number of previous studies on the issue of risk perception in developing countries. As a further step it is recommended to estimate the effect of ex-ante climate risk management on the vulnerability to poverty of households in order to have a full linkage between risk experience, risk perception, risk management and transient poverty. Establishing that linkage would allow drawing conclusions on the welfare implications of climate risk perception and, thus, facilitate the design of social risk management policies. Different concepts of vulnerability could be compared in order to test for the sensitivity of results.

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Appendices

Appendix A: Results of first stage OLS regression

OLS regression of number of weather shocks of high/medium severity against exogenous covariates and selected instruments (N=277)

	OLS		
	Coef.	t-value	
Household characteristics:			
Ethnicity dummy	-0.2830266	-1.96	*
Household size	0.0797703	1.88	*
Financial assets value	-0.0000009	-0.37	
Tangible assets value	0.0000005	1.09	
Household head education	-0.0084045	-0.52	
Village/district characteristics:			
Time to market	0.0043769	1.80	*
Ha Tinh dummy	-0.3923979	-1.11	
Dak Lak dummy	-0.5577195	-2.11	**
Lost main occupation weeks:			
Active members	0.0216648	1.50	
Dependent members	-0.0137726	-4.06	***
Risk:			
Risk score	-0.0001179	-7.49	***
Exogenous instruments:			
Elevation	-0.0013109	-2.75	***
Constant	2.0947100	4.52	***
P > F (joint significance)	0.0000		
R^2	0.1934		

Source: DFGFOR756 base survey and Jarvis et al. (2009) (for exogenous instruments for weather shocks). Note: *P<0.1, **P<0.05, ***P<0.01.

Appendix B: LP matrix 2007 (upper part)

	Spring rice				Autumn rice				Cassava			Corn			Banana			Chicken			
	Variable costs	Sell	Consume	Buy	Variable costs	Sell	Consume	Buy	Variable costs	Sell	Consume	Variable costs	Sell	Consume	Variable costs	Sell	Consume	Gross margin	Consume	Buy	Area
Unit of analysis	ha	kg	kg	kg	ha	kg	kg	kg	ha	kg	kg	ha	kg	kg	ha	branch	kg	head	head	head	m²
Objective function (PPPUS$)	-615				-29				0	0.1		-1130	0.5		0	2.96		27.9		-37	
Spring rice balance	-2479	1	1																		
Autumn rice balance					-2935	1	1														
Total rice consumption needs			1	1			1	1													
Cassava balance									-7250	1	1										
Cassava consumption needs											1										
Corn balance												-1120	1	1							
Corn consumption needs														1							
Banana balance															-331	1	1				
Banana consumption needs																	1				
Chicken balance																		-0.4	1	1	
Chicken consumption need																			1		
Chicken stall area balance																		1			-7
Pig replacement control																					
Pig balance																					
Pig litter balance																					
Stall area balance 1 (pig fatt)																					
Stall area balance 2 (pig piglet)																					
Fuel wood consumption need																					
Forest extraction constraint																					
Land constraint intra-year period 1	1								1			1			1						
Land constraint intra-year period 2					1																
Land balance	-1				1																
Land constraint chicken																					1
Land constraint pig fatt																					
Land constraint pig piglet																					
Hard labor constraint Jan																					
Mixed labor constraint Jan	76.6											20			2.5			0.16			
Hard labor constraint Feb																					
Mixed labor constraint Feb	66.6								105			57.5			2.5			0.16			
Hard labor constraint Mar																					
Mixed labor constraint Mar	62.5								40			25			20			0.16			
Hard labor constraint Apr																					
Mixed labor constraint Apr									55						10			0.16			
Hard labor constraint May																					
Mixed labor constraint May	80								70						5			0.16			
Hard labor constraint Jun																					
Mixed labor constraint Jun					98.48							33.3			7.5			0.16			

Appendix B: LP matrix 2007 (upper part, continued)

Pig							Fuel wood extraction												Forest extraction												Further consumption
Breeding sow variable costs	Pig (fattening) variable costs	Pig (fattening) Sell	Rear sow variable costs	Rear sow Buy	Area 1 (pig fatt)	Area 2 (pig piglet)	Jan	Feb	Mrz	Apr	Mai	Jun	Jul	Aug	Sep	Okt	Nov	Dez	Jan	Feb	Mrz	Apr	Mai	Jun	Jul	Aug	Sep	Okt	Nov	Dez	
head	head	head	head	head	m²	m²	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	man days	man days	man days	man days	man days	man days	man days	man days	man days	man days	man days	man days	1000 VND
-47.4	-23.7	59.28	-47.4	-316			0	0	0	0	0	0	0	0	0	0	0	0									5	5	5	5	
0.25			-1	-1																											
	-1	1																													
-9	1		1																												
	1				-0.5																										
1			1			-0.33																									
							1	1	1	1	1	1	1	1	1	1	1	1									1	1	1	1	
						1																										
						1																										
							0												1												
4.922	0.938		4.922																												
								0												1											
4.922	0.938		4.922																												
									0												1										
4.922	0.938		4.922																												
										0												1									
4.922	0.938		4.922																												
											0												1								
4.922	0.938		4.922																												
												0												1							
4.922	0.938		4.922																												

Appendix B: LP matrix 2007 (upper part, continued)

Transfer cash surplus											Hard labor transfer	Negative deviation								Consumption value	Income from remittances (hh)	Income from remittances (friends)	Income from house and land	Income from public transfer	Asset depreciation	Asset costs		RHS
1	2	3	4	5	6	7	8	9	10	11		Risk 1	Risk 2	Risk 3	Risk 4	Risk 5	Risk 6	Risk 7	Risk 8									
1000 VND											man days	1000 VND								1000 VND	1000 VND	1000 VND	1000 VND	1000 VND	1000 VND	1000 VND		
																					1	1	1	1	-1	-1		Max
																											<=	0
																											<=	0
																											=	1012
																											<=	0
																											>=	0
																											<=	0
																											>=	12.5
																											<=	0
																											>=	2
																											<=	0
																											>=	3
																											<=	0
																											<=	0
																											<=	0
																											<=	0
																											<=	0
																											<=	0
																											=	2410
																											<=	25
																											<=	0.158
																											<=	0.158
																											<=	0
																											<=	1.46
																											<=	7
																											<=	4
											1																<=	41.67
											-1																<=	12.5
											1																<=	41.67
											-1																<=	12.5
											1																<=	41.67
											-1																<=	12.5
											1																<=	41.67
											-1																<=	12.5
											1																<=	41.67
											-1																<=	12.5
											1																<=	41.67
											-1																<=	12.5

Appendix C: LP matrix 2007 (lower part)

Hard labor constraint Jul																				
Mixed labor constraint Jul					16.67				30						7.5			0.16			
Hard labor constraint Aug																					
Mixed labor constraint Aug					20				30						10			0.16			
Hard labor constraint Sep																					
Mixed labor constraint Sep					83.3										5			0.16			
Hard labor constraint Oct																					
Mixed labor constraint Oct									37.5									0.16			
Hard labor constraint Nov																					
Mixed labor constraint Nov									37.5									0.16			
Hard labor constraint Dec																					
Mixed labor constraint Dec									47.5									0.16			
Consumption constraint January																					
Consumption constraint February																					
Consumption constraint March																					
Consumption constraint April																					
Consumption constraint May																					
Consumption constraint June																					
Consumption constraint July																					
Consumption constraint August																					
Consumption constraint September																					
Consumption constraint October																					
Consumption constraint November																					
Consumption constraint December																					
Cash constraint January	60.27											148.9			0.49	-0.2		0.23			
Cash constraint February	94.85								146.2			23.7			0.49			0.23			
Cash constraint March	14.98								11.86			19.8			5.89	-0.2		0.23			
Cash constraint April									11.86			2.5			2.35			0.23			
Cash constraint May				0.8												-0.2		0.23			
Cash constraint June					162								-0.5					0.23			
Cash constraint July					14.82											-0.2		0.23			
Cash constraint August																		-28	31	36.8	
Cash constraint September								0.8								-0.2		0.23			
Cash constraint October																		0.23			
Cash constraint November																-0.2		0.23			
Cash constraint December										-0								0.23			
Yield risk row state of nature 1	815.7				1633				988			-272			1482			27.9			
Yield risk row state of nature 2	195.7				1633				988			-1130			613			27.9			
Yield risk row state of nature 3	-58.6				1633				988			-1130			1482			27.9			
Yield risk row state of nature 4	815.7				679.2				0			-272			0			27.9			
Yield risk row state of nature 5	-615				1633				988			-1130			613			27.9			
Yield risk row state of nature 6	195.7				679.2				0			-1130			0			27.9			
Yield risk row state of nature 7	-58.6				679.2				0			-1130			0			27.9			
Yield risk row state of nature 8	-615				679.2				0			-1130			0			27.9			
Expected shortfall from target																					
Income from remittances (hh)																					
Income from remittances (friends)																					
Income from house and land balance																					
Income from public transfer balance																					
Depreciation balance																					
Asset costs																					

Appendix C: LP matrix 2007 (lower part, continued)

													0												1						
4.922			4.922																												
														0												1					
4.922			4.922																												
															0												1				
4.922			4.922																												
																0												1			
4.922			4.922																												
																	0												1		
4.922			4.922																												
																		0												1	
4.922			4.922																												
																															1
																															1
																															1
																															1
																															1
																															1
																															1
																															1
																															1
																															1
																															1
																															1
0	0		0	0																											1
0	0		0																												1
0	3.952		0																												1
0	3.952		0																												1
0	3.952		0																												1
0	3.952		0																												1
0		3.952	0																												1
0			0																												1
0			-59.3																								0				1
0			0																									0			1
0			0																										0		1
0			0																											0	1
-47.4	-23.7	59.28	-47.4				0	0	0	0	0	0	0	0	0	0	0	0									5	5	5	5	
-46.4	-23.7	59.28	-47.4				0	0	0	0	0	0	0	0	0	0	0	0									5	5	5	5	
-45.4	-23.7	59.28	-47.4				0	0	0	0	0	0	0	0	0	0	0	0									5	5	5	5	
-44.4	-23.7	59.28	-47.4				0	0	0	0	0	0	0	0	0	0	0	0									5	5	5	5	
-43.4	-23.7	59.28	-47.4				0	0	0	0	0	0	0	0	0	0	0	0									5	5	5	5	
-42.4	-23.7	59.28	-47.4				0	0	0	0	0	0	0	0	0	0	0	0									5	5	5	5	
-41.4	-23.7	59.28	-47.4				0	0	0	0	0	0	0	0	0	0	0	0									5	5	5	5	
-40.4	-23.7	59.28	-47.4				0	0	0	0	0	0	0	0	0	0	0	0									5	5	5	5	

Appendix C: LP matrix 2007 (lower part, continued)

											1																<=	41.67
											-1																<=	12.5
											1																<=	41.67
											-1																<=	12.5
											1																<=	41.67
											-1																<=	12.5
											1																<=	41.67
											-1																<=	12.5
											1																<=	41.67
											-1																<=	12.5
											1																<=	41.67
											-1																<=	12.5
																											>=	55.09
																											>=	55.09
																											>=	55.09
																											>=	55.09
																											>=	55.09
																											>=	55.09
																											>=	55.09
																											>=	55.09
																											>=	55.09
																											>=	55.09
																											>=	55.09
																											>=	55.09
1																					-1	-1				1	<=	652.1
-1	1																										<=	0
	-1	1																									<=	0
		-1	1																								<=	0
			-1	1																							<=	0
				-1	1																						<=	0
					-1	1																					<=	0
						-1	1																				<=	0
							-1	1																			<=	0
								-1	1																		<=	0
									-1	1																	<=	0
										-1																	<=	0
												1									1	1	1	1	-1	-1	>=	1750
													1								1	1	1	1	-1	-1	>=	1750
														1							1	1	1	1	-1	-1	>=	1750
															1						1	1	1	1	-1	-1	>=	1750
																1					1	1	1	1	-1	-1	>=	1750
																	1				1	1	1	1	-1	-1	>=	1750
																		1			1	1	1	1	-1	-1	>=	1750
																			1		1	1	1	1	-1	-1	>=	1750
												0.51	0.09	0.11	0.19	0.02	0.03	0.04	0.01								<=	x
																					1						=	3.592
																						1					=	17.96
																							1				=	380.1
																								1			=	22.29
																									1		=	1.28
																										1	=	45.42

Appendix D: LP matrix 2008 (upper part)

	Spring rice				Autumn rice				Cassava			Corn			Banana			Chicken			
	Variable costs	Sell	Consume	Buy	Variable costs	Sell	Consume	Buy	Variable costs	Sell	Consume	Variable costs	Sell	Consume	Variable costs	Sell	Consume	Gross margin	Consume	Buy	Area
Unit of analysis	ha	kg	kg	kg	ha	kg	kg	kg	ha	kg	kg	ha	kg	kg	ha	branch	kg	head	head	head	m²
Objective function (PPPUS$)	-938				-26.6				0	0.1		-1598	0.5		0	3.08		25.5		-34	
Spring rice balance	-2479	1	1																		
Autumn rice balance					-2935	1	1														
Total rice consumption needs			1	1			1	1													
Cassava balance									-7250	1	1										
Cassava consumption needs											1										
Corn balance												-1120	1	1							
Corn consumption needs														1							
Banana balance															-331	1	1				
Banana consumption needs																	1				
Chicken balance																		-0.4	1	1	
Chicken consumption need																			1		
Chicken stall area balance																		1			-7
Pig replacement control																					
Pig balance																					
Pig litter balance																					
Stall area balance 1 (pig fatt)																					
Stall area balance 2 (pig piglet)																					
Fuel wood consumption need																					
Forest extraction constraint																					
Land constraint intra-year period 1	1								1			1			1						
Land constraint intra-year period 2					1																
Land balance	-1				1																
Land constraint chicken																					1
Land constraint pig fatt																					
Land constraint pig piglet																					
Hard labor constraint Jan																					
Mixed labor constraint Jan	76.6											20			2.5			0.16			
Hard labor constraint Feb																					
Mixed labor constraint Feb	66.6								105			57.5			2.5			0.16			
Hard labor constraint Mar																					
Mixed labor constraint Mar	62.5								40			25			20			0.16			
Hard labor constraint Apr																					
Mixed labor constraint Apr									55						10			0.16			
Hard labor constraint May																					
Mixed labor constraint May	80								70						5			0.16			
Hard labor constraint Jun																					
Mixed labor constraint Jun					98.48							33.3			7.5			0.16			

Appendix D: LP matrix 2008 (upper part, continued)

Pig							Fuel wood extraction												Forest extraction												Further consumption
Breeding sow variable costs	Pig (fattening) variable costs	Pig (fattening) Sell	Rear sow variable costs	Rear sow Buy	Area 1 (pig fatt)	Area 2 (pig piglet)	Jan	Feb	Mrz	Apr	Mai	Jun	Jul	Aug	Sep	Okt	Nov	Dez	Jan	Feb	Mrz	Apr	Mai	Jun	Jul	Aug	Sep	Okt	Nov	Dez	
head	head	head	head	head	m²	m²	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	man days	man days	man days	man days	man days	man days	man days	man days	man days	man days	man days	man days	1000 VND
-43.5	-21.7	54.36	-43.5	-290			0	0	0	0	0	0	0	0	0	0	0	0									5	5	5	5	
0.25			-1	-1																											
	-1	1																													
-9	1		1																												
	1				-0.5																										
1			1			-0.33																									
							1	1	1	1	1	1	1	1	1	1	1	1													
																											1	1	1	1	
						1																										
							1																									
							0												1												
4.922	0.938		4.922																												
								0												1											
4.922	0.938		4.922																												
									0												1										
4.922	0.938		4.922																												
										0												1									
4.922	0.938		4.922																												
											0												1								
4.922	0.938		4.922																												
												0																			
4.922	0.938		4.922																												
4.922	0.938		4.922																												

Appendix D: LP matrix 2008 (upper part, continued)

Transfer cash surplus 1	2	3	4	5	6	7	8	9	10	11	Hard labor transfer	Negative deviation Risk 1	Risk 2	Risk 3	Risk 4	Risk 5	Risk 6	Risk 7	Risk 8	Consumption value	Income from remittances (hh)	Income from remittances (friends)	Income from house and land	Income from public transfer	Asset depreciation	Asset costs		**RHS**
1000 VND											man days	1000 VND								1000 VND	1000 VND	1000 VND	1000 VND	1000 VND	1000 VND	1000 VND		
																					1	1	1	1	-1	-1		Max
																											<=	0
																											<=	0
																											=	1012
																											<=	0
																											>=	0
																											<=	0
																											>=	12.5
																											<=	0
																											>=	3
																											<=	0
																											>=	3
																											<=	0
																											<=	0
																											<=	0
																											<=	0
																											<=	0
																											<=	0
																											=	2410
																											<=	25
																											<=	0.1575
																											<=	0.1575
																											<=	0
																											<=	1.46
																											<=	7
																											<=	4
											1																<=	41.67
											-1																<=	12.5
											1																<=	41.67
											-1																<=	12.5
											1																<=	41.67
											-1																<=	12.5
											1																<=	41.67
											-1																<=	12.5
											1																<=	41.67
											-1																<=	12.5
											1																<=	41.67
											-1																<=	12.5

Appendix E: LP matrix 2008 (lower part)

Hard labor constraint Jul																				
Mixed labor constraint Jul					16.67				30						7.5			0.16		
Hard labor constraint Aug																				
Mixed labor constraint Aug					20				30						10			0.16		
Hard labor constraint Sep																				
Mixed labor constraint Sep					83.3										5			0.16		
Hard labor constraint Oct																				
Mixed labor constraint Oct									37.5									0.16		
Hard labor constraint Nov																				
Mixed labor constraint Nov									37.5									0.16		
Hard labor constraint Dec																				
Mixed labor constraint Dec									47.5									0.16		
Consumption constraint January																				
Consumption constraint February																				
Consumption constraint March																				
Consumption constraint April																				
Consumption constraint May																				
Consumption constraint June																				
Consumption constraint July																				
Consumption constraint August																				
Consumption constraint September																				
Consumption constraint October																				
Consumption constraint November																				
Consumption constraint December																				
Cash constraint January	55.27											136.5			0.45	-0.5		0.21		
Cash constraint February	86.98								134.1			21.74			0.45			0.21		
Cash constraint March	13.74								10.87			18.12			5.4	-0.5		0.21		
Cash constraint April									10.87			2.265			2.15			0.21		
Cash constraint May				1.3												-0.5		0.21		
Cash constraint June					148.6								-0.5					0.21		
Cash constraint July					13.59											-0.5		0.21		
Cash constraint August																		-26	28	33.7
Cash constraint September								1.3								-0.5		0.21		
Cash constraint October																		0.21		
Cash constraint November																-0.5		0.21		
Cash constraint December										-0								0.21		
Yield risk row state of nature 1	1448				2746				996.6			-725			1540			25.5		
Yield risk row state of nature 2	414.3				2746				996.6			-1598			637			25.5		
Yield risk row state of nature 3	-10				2746				996.6			-1598			1540			25.5		
Yield risk row state of nature 4	1448				1155				0			-725			0			25.5		
Yield risk row state of nature 5	-938				2746				996.6			-1598			637			25.5		
Yield risk row state of nature 6	414.3				1155				0			-1598			0			25.5		
Yield risk row state of nature 7	-10				1155				0			-1598			0			25.5		
Yield risk row state of nature 8	-938				1155				0			-1598			0			25.5		
Expected shortfall from target																				
Income from remittances (hh)																				
Income from remittances (friends)																				
Income from house and land balance																				
Income from public transfer balance																				
Depreciation balance																				
Asset costs																				

Appendix E: LP matrix 2008 (lower part, continued)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
													0												1						
4.922			4.922																												
														0												1					
4.922			4.922																												
															0												1				
4.922			4.922																												
																0												1			
4.922			4.922																												
																	0												1		
4.922			4.922																												
																		0												1	
4.922			4.922																												
																														1
																														1
																														1
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0	0		0	0																											1
0	0		0																												1
0	3.624		0																												1
0	3.624		0																												1
0	3.624		0																												1
0	3.624		0																												1
0		3.624	0																												1
0			0																												1
0			-54.4																								-4.53				1
0			0																									-4.53			1
0			0																										-4.53		1
0			0																											-4.5	1
-43.5	-21.7	54.36	-43.5				0	0	0	0	0	0	0	0	0	0	0	0									5	5	5	5	
-42.5	-21.7	54.36	-43.5				0	0	0	0	0	0	0	0	0	0	0	0									5	5	5	5	
-41.5	-21.7	54.36	-43.5				0	0	0	0	0	0	0	0	0	0	0	0									5	5	5	5	
-40.5	-21.7	54.36	-43.5				0	0	0	0	0	0	0	0	0	0	0	0									5	5	5	5	
-39.5	-21.7	54.36	-43.5				0	0	0	0	0	0	0	0	0	0	0	0									5	5	5	5	
-38.5	-21.7	54.36	-43.5				0	0	0	0	0	0	0	0	0	0	0	0									5	5	5	5	
-37.5	-21.7	54.36	-43.5				0	0	0	0	0	0	0	0	0	0	0	0									5	5	5	5	
-36.5	-21.7	54.36	-43.5				0	0	0	0	0	0	0	0	0	0	0	0									5	5	5	5	

Appendix E: LP matrix 2008 (lower part, continued)

											1																<=	41.67
											-1																<=	12.5
											1																<=	41.67
											-1																<=	12.5
											1																<=	41.67
											-1																<=	12.5
											1																<=	41.67
											-1																<=	12.5
											1																<=	41.67
											-1																<=	12.5
											1																<=	41.67
											-1																<=	12.5
																											>=	50.5167
																											>=	50.5167
																											>=	50.5167
																											>=	50.5167
																											>=	50.5167
																											>=	50.5167
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																											>=	50.5167
																											>=	50.5167
																											>=	50.5167
																											>=	50.5167
																											>=	50.5167
1																					-1	-1				1	<=	597.96
-1	1																										<=	0
	-1	1																									<=	0
		-1	1																								<=	0
			-1	1																							<=	0
				-1	1																						<=	0
					-1	1																					<=	0
						-1	1																				<=	0
							-1	1																			<=	0
								-1	1																		<=	0
									-1	1																	<=	0
										-1																	<=	0
												1									1	1	1	1	-1	-1	>=	1749.84
													1								1	1	1	1	-1	-1	>=	1749.84
														1							1	1	1	1	-1	-1	>=	1749.84
															1						1	1	1	1	-1	-1	>=	1749.84
																1					1	1	1	1	-1	-1	>=	1749.84
																	1				1	1	1	1	-1	-1	>=	1749.84
																		1			1	1	1	1	-1	-1	>=	1749.84
																			1		1	1	1	1	-1	-1	>=	1749.84
												0.51	0.09	0.11	0.19	0.02	0.03	0.04	0.01								<=	x
																					1						=	3.29422
																						1					=	16.4729
																							1				=	348.564
																								1			=	20.4394
																									1		=	1.17418
																										1	=	41.6488