Dynamics of land use patterns in biodiversity rich farming systems of India

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Der Trend der Diversifizierung des Anbaus von Grundnahrungsmitteln wie Reis zu hochwertigen Marktfrüchten (high value crops, HVCs), wie beispielsweise Obst und Gemüse, kann in allen großen Reis produzierenden Ländern Asiens beobachtet werden. Aktuelle Literatur zeigt, dass der Anteil von HVCs in Indien sowohl in Bezug auf die Anbaufläche als auch auf den Gesamtwert der Produktion steigt. Diversifizierung hin zu HVCs wird, vor allem für Kleinbauern und in Indien, als armutsbekämpfend und einkommenssteigernd betrachtet. Jedoch ist der Wechsel von Nahrungspflanzen zu Marktfrüchten kein reibungsloser Prozess und hat signifikante ökologische Folgen. FAO Prognosen zeigen, dass der steigende Bedarf der wachsenden Bevölkerung der asiatischen Länder in Zukunft nicht durch selbstversorgenden Grundnahrungsmittelanbau zu decken sein wird. Darüber hinaus ist die Produktion von HVCs durch mangelhafte Marktstrukturen und fehlende infrastrukturelle Unterstützung zu einem riskanten Unterfangen geworden. Ein hoher Anteil der HVC Produzenten, vor allem Kleinbauern, haben sich verschuldet. Kerala in Südindien hat den höchsten Nahrungsmittel zu Nicht-Nahrungsmittel Diversifizierungsindex in Indien. In Kerala wandelt sich die landwirtschaftliche Landnutzung vor allem von Reisanbausystemen zu Marktfrüchten, wie beispielsweise Kautschuk, Bananen oder Kokosnüssen. Dies führte zu einer alarmierenden Nahrungsmittelknappheit in Kerala, da die derzeitige Produktion nur 15% der benötigten Grundnahrungsmittel abdeckt. Trotz verschiedener Versuche der Regierung Keralas, die Reisproduktion anzukurbeln, nahm diese noch ab. Zudem gibt es einen landwirtschaftlichen Notstand in Kerala, und zwar vornehmlich unter den Bauern, die HVCs kultivieren.

Das übergeordnete Ziel dieser Dissertation ist es, die Dynamiken und Auswirkungen der sich ändernden Landnutzungsmuster von Kleinbauern am Beispiel von Kerala zu analysieren. Konkrete Forschungsziele sind folgende: 1) Untersuchung der Makroanreize

(exogen zu den Haushalten) der Landtransformation von Reisanbau hin zu HVCs, 2) Abschätzung der kurz- und langfristigen Reisflächenallokation als Reaktion auf temporäre Änderungen in Preis und Nicht-Preis Faktoren, 3) Analyse der Determinanten, die die HVC-Einführung unter landwirtschaftlichen Haushalten beeinflussen, 4) Abschätzung der Wohlfahrtswirkung von HVC-Adoption durch kleine und marginale landwirtschaftliche Haushalte, und 5) Analyse der Wirkung von Methanemissionssteuern auf die Produktion von Rohreis.

Die Dissertation ist eingebettet in ein größeres Projekt (BioDivA), das auf die nachhaltige Landnutzung und den Erhalt von Biodiversität im Wayanad District in Kerala abzielt. Fokusgruppendiskussionen, partizipative Bewertungen im ländlichen Raum, und Workshops mit Interessenvertretern wurden zwischen 2010-2013 durchgeführt, um Hinweise auf Muster der Landnutzungsveränderung zu sammeln. Die Ergebnisse dieser Diskussionen, nebst Daten auf Staats- bzw. Distriktebene, die den Zeitraum von 1983-2011 abdecken, sind Grundlagen für die Analyse der politischen und soziodemografischen Ursachen der Landnutzungs-veränderungen. Die Ergebnisse zeigen, dass unbeabsichtigte Effekte von Politik, Politikkonflikte und inadäquate sektorale Integration von Politik die Hauptmakroanreize für den Wandel der Landnutzung weg von Nahrungsmitteln sind. Die geringe Wirtschaftlichkeit des Rohreisanbaus, der Mangel an Arbeitskräften in der Landwirtschaft und der Bevölkerungsdruck auf dem Land wurden als die hauptsächlichen sozioökonomischen Ursachen für den Landnutzungswandel identifiziert.

Um ein tieferes Verständnis von Landnutzungsdynamiken zu erhalten, wird die Beziehung zwischen der Flächenverteilung für Reis in Wayanad und den zeitlichen Veränderungen von Preisen, Löhnen und Regenfall analysiert. Dafür werden Daten von 1987-2009 zugrunde gelegt. Mit Hilfe des ‚Auto Regressive Distributive Lags' (ARDL) Ansatzes zur Ko-Integration und der Bounds Testing Methode werden die Kurz- und Langzeitelastizitäten der Verteilung von Flächen für den Reisanbau geschätzt. Die Ergebnisse zeigen, dass Kleinbauern positiv auf Preis- und negativ auf Lohnfaktoren reagieren, und zwar sowohl kurz- als auch langfristig. Interventionen wie eine Erhöhung der Preise, die die Bauern für Rohreis erhalten, und Arbeitsreformen zur Lohnerhöhung könnten die Versorgung von Rohreis in Wayanad verbessern. Die endogenen Faktoren, die die Entscheidung des Haushalts beeinflussen, HVCs statt Reis anzubauen, werden mit Hilfe eines Multi-

nomialen Logit Regressions-Modells überprüft. Die heterogenen Wohlfahrtseffekte von HVC-Adoption werden mit der Multinomialen Endogenen Switching Regression geschätzt. Die Basis dieser Analysen ist ein Querschnittsdatensatz von Haushalten in Wayanad Distrikt von 2011. Insgesamt wurden 304 rurale Haushalte zufällig ausgewählt und interviewt. Die Ergebnisse zeigen, dass der Zugang von Transportmitteln zur Farm, die Anzahl von Feldern, auf denen der Haushalt etwas anbaut, die Entfernung vom Wohnhaus zur Farm und die Betriebsgröße Faktoren sind, die die Entscheidung, HVC einzuführen, beeinflussen. Das Ergebnis der Folgenabschätzung von HVC Adoption auf die Wohlfahrt weist nach, dass die Adoption von HVCs einen positiven Effekt auf das Haushaltseinkommen und die Ausgaben hat. Außerdem zeigt sich, dass die Haushalte, die HVC nur teilweise eingeführt haben, einen größeren Wohlfahrtseffekt erreicht haben als die Haushalte, die ihren Anbau komplett auf HVC umgestellt haben.

Die Wirkung von Methanemissionssteuern als ein Verminderungsmechanismus für Treibhausgase (GHG) im Reissektor wurde untersucht basierend auf Reisproduktions- und Methanemissionsdaten auf nationaler Ebene. Das Ergebnis des iso-elastischen Angebotsmodells zeigt, dass Emissionssteuern auf Reis einen negativen Effekt auf die Reisproduktion und die Produzentenwohlfahrt haben könnte. Für eine erfolgreiche Implementierung von Emissionssteuern ist die Entwicklung von kosteneffektiven GHG-Verminderungsmaßnahmen auf Betriebsebene nötig, die die Wohlfahrtsverluste ausgleichen.

Schlüsselwörter: Landnutzungswandel, Adoption, hochwertige Marktfrüchte, Wohlfahrtseffekt, Reisanbau, Emissionen, Indien

ABSTRACT

The trend of diversification from staple food, rice, to high value crops (HVCs), such as, fruits and vegetables has been observed in major rice producing countries of Asia. Recent literature shows that the share of HVCs in India is increasing both in terms of area cropped and total value of the output. Diversification to HVCs is largely regarded as poverty reducing and income increasing particularly for small and marginal farmers in India. However, transition from food crops to commercial crops is not a frictionless process and has significant environmental consequences. FAO projections show that the thin line of self sufficiency in food grain production of Asian countries may not hold true in the future due to the inability of the countries to meet the increasing demand of the burgeoning population. In addition, the existing market imperfections and lack of infrastructural support mainly for perishables, such as, high value fruits and vegetables, have made the production of HVCs a riskier enterprise in India. A high degree of indebtedness is observed among the HVC growers, especially, the small and marginal growers. The state of Kerala in Southern India has the highest food crop to non-food crop diversification index in India. Specifically, the agricultural land use is changing from wetland paddy system to cash crops, such as, rubber, banana and coconut in Kerala. This has resulted in alarming levels of food deficit in the state, as the state currently produces only 15 per cent of its required food grain demand. Despite various efforts from the state government, the rice production has not picked up any pace, but is declining. On the other hand, there is an increasing rate of agrarian distress in the state, more prevalent among the farmers who adopted HVCs.

The overall objective of this dissertation is to analyse the dynamics of land use pattern of small and marginal farmers and its impacts using the example of Kerala. Specific research objectives are outlined as below: 1) To examine the macro drivers (exogenous to the household) influencing land transformation from paddy farming to HVCs. 2) To

estimate the short-run and long-run paddy area allocation in response to temporal changes in price and non-price factors. 3) To analyse the household determinants influencing HVC adoption among agricultural households. 4) To estimate the welfare impacts of HVC adoption by small and marginal farming households and 5) To analyse the impact of methane emission taxes on paddy production.

The dissertation is embedded in the framework of a larger project (BioDiva), which is aimed at sustainable land use and biodiversity conservation in Wayanad district of Kerala. Focus group discussions, participatory rural appraisals and stakeholder workshops were conducted during the period of 2010-2013 to gather evidence on land use change pattern. Outputs from these discussions, along with state and district level data, covering a period of 1983-2011, are used to analyse the policy and socio-demographic causes of land use transitions. The results reveal unintended policy idiosyncrasies, policy conflicts and inadequate sectoral integration of policies as the major macro drivers causing change in land use from food crops. Low economic viability of paddy farming, shortage of agricultural labour and population pressure on land are identified as major socio-economic causes behind agricultural land use change.

In order to gain deeper understanding of the land use dynamics, the relationship between the area allocation of rice in Wayanad and the temporal changes in prices, wages and rainfall is analysed. Data covering a period of 1987-2009 is used for this purpose. Auto Regressive Distributive Lags Approach (ARDL) of co-integration and bounds testing method are used to estimate the short- and long-run elasticities of rice area allocation. The model results reveal that farmers respond positively to price and negatively to wage factors in the short as well as in the long run. Interventions to improve the price received by farmers for paddy and labour reforms to address higher wage rates might improve the supply response of paddy in Wayanad. The factors endogenous to the household that influence the household decision to adopt HVCs over rice are studied by using a multinomial logit regression model. The heterogeneous welfare impacts of HVC adoption are also assessed by multinomial endogenous switching regression. The data basis of these analyses is a cross sectional household survey conducted in the year of 2011 in Wayanad district. A total of 304 agricultural households were randomly selected and interviewed. The results showed that transport access to farm, number of sub-plots the household

cultivated, distance to farm from dwelling and farm size as the factors determining the HVC adoption decision. The result of the welfare impacts of HVC adoption proved that adoption has a positive impact on household income and expenditure. Furthermore, the households that partially adopted HVCs had higher welfare than those that entirely adopted HVCs.

The impact of methane emission taxes as a greenhouse gas (GHG) mitigation mechanism in rice is studied based on the production price and methane emissions data at national level. The outcome of iso-elastic supply model reveals that emission taxes on rice might have negative impact on the rice production and producer's welfare. For successful implementation of emission taxes, development of cost-effective mitigation measures at the farm level offsetting the welfare losses of small holders is essential.

Keywords: land use change, adoption, high value crops, welfare impact, paddy farming, emissions.

CONTENTS

LIST OF ABBREVIATIONS

Acronyms / Abbreviations

₹	Indian Rupee
AAY	*Antyodaya Anna Yojana*
APL	Above Poverty Line
ARDL	Auto Regressive Distributive Lag
BPL	Below Poverty Line
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
DES	Directorate of Economics and Statistics
FAO	Food and Agriculture Organisation of the United Nations
FAOSTAT	Food and Agriculture Organisation of the United Nations Statistics
GHG	Green House Gas
GWP	Global Warming Potential
HDI	Human Development Index
HVC	High Value Crop
IAAE	International Association of Agricultural Economists
IMR	Inverse Mills Ratio
IPCC	Intergovernmental Panel on Climate Change
MGNREGA	The Mahatma Gandhi National Rural Employment Guarantee Act
Mha	Million hectare
MPC	Market Price of Carbon
MSP	Minimum Support Price
Mt	Million tonne

SBIC	Schwarz's Bayesian Information Criterion
SHG	Self Help Groups
SPC	Shadow Price of Carbon
TPDS	Targeted Public Distribution System
t	tonne
UEC	Unrestricted Error Correction
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
US$	US Dollar
WPI	Wholesale Price Index

Chapter **1**

INTRODUCTION

1.1 Background and problem statement

Rice plays a pivotal role in Indian agriculture. India is the world's second largest rice producer and exporter of rice (FAOSTAT, 2012). Rice is cultivated on 44 million ha (35% of total area under food grains) contributing to around 40% of the total food grain production in India (Government of India, 2015), thus making rice the most important food crop of the country. However, the Indian agricultural sector has undergone considerable changes since the 1990s. Lately, it is observed that agriculture is under transition from food crops towards high value crops (HVCs) and livestock products (Rada, 2016). During the past two decades, the area under HVCs in India has increased (Kumar & Gupta, 2015; Mittal & Hariharan, 2016). As argued by MacRae (2016), *"Indian agriculture is now poised between two futures—one of increasing technology-driven intensification and integration into national and global markets—the other [....] ecologically based forms of small-farming producing for more local consumption"*.

Rice paddies play an important role in shaping the food and agricultural sector of Asia. It is not only the major staple food of Asia but is also an important source of income and employment for many resource poor rural farming households. Over 90% of the production and consumption of rice is concentrated in Asia and the Asia-Pacific region (Papademetriou, Dent, & Herath, 2000). Rice accounts for 23% of world's total cropped area and 29% of total grain output (Mew, Brar, Peng, Dawe, & Hardy, 2003). Since the era of Green revolution, the production of rice has kept pace with the consumption levels.

As a result, it has a significant contribution to poverty reduction and enhancing the food security thereby making most of the Asian countries food self-sufficient.

Literature reveals that Asian rice farmers drift away from rice systems by adopting non-rice crops, especially horticultural crops (Pingali, 1997). This drift from food crops, such as, paddy rice to non-food HVCs is considered to be in response to a variety of factors such as, declining profits, commercialization of agriculture and rapid technological progress in agriculture (Papademetriou et al., 2000; Pingali, 2004). At the household level, it is viewed as crop diversification, as individual farmers decide to opt out of subsistence farming to more market-oriented crops. At the regional or macro level, it is viewed as a change in land use dynamics from a wetland paddy system to a more resource intensive cash crop system. From the perspective of a developing country, this change in agriculture has both positive and negative consequences.

On the negative side, firstly, this shift is found to have a profound impact on the food security of small and marginal farmers in developing countries (Babu, Gajanan, & Sanyal, 2014). The Food and Agriculture Organisation (FAO) describes it as *"the thin line of self-sufficiency experienced by many countries is disappearing fast"*(Papademetriou et al., 2000). Even though the demand growth rate of rice is decreasing, the supply rate is slowing down at a faster pace (Pingali, Hossain, & Gerpacio, 1997). According to the projections from FAO, considering the current rate of population growth in Asian countries, there will be an unmet demand for rice by 2025 (Papademetriou et al., 2000). Recent studies reveal that rice yields have been stagnating (Ray, Ramankutty, Mueller, West, & Foley, 2012) and an additional 112 million tons of rice would be required by 2040 to meet the additional demand (Mohanty, 2015). Nonetheless, this surge in demand needs to be met with existing or even declining production resources such as, land, water and scarce labour (Papademetriou et al., 2000).

Secondly, when wetland paddy system is replaced by commercial cash crop cultivation, it can have significant environmental consequences (Pingali & Rosegrant, 1995), such as, loss in biodiversity or water scarcity. However, rice that is primarily grown as a wetland crop in Asia[1] (Barker et al., 1985) provides significant ecosystem services and functions

[1]According to Barker, Herdt, and Rose (1985) 90% of rice is grown under wetland conditions where the rice fields are flooded for almost throughout the whole cultivation period. The rest being upland rice, is grown in low rainfall regions and have very low productivity levels.

(Natuhara, 2013). The Ramsar Convention classifies rice paddy fields as human made wetlands that constitute for about 18% of the total global wetlands. They play a major role in regulating the rainfall pattern, maintaining the floral and faunal diversity and in providing climatic stability (Ambastha, Hussain, & Badola, 2007). The wise use of paddy wetland can partially compensate for the loss of natural wetlands (Yoon, 2009).

On the positive side, diversification to HVCs can be an important strategy to augment income and reduce poverty (Birthal, Roy, & Negi, 2015) of rice farmers in a developing country. As argued by Mew et al.(2003), many of these rice farmers in developing countries remain poor. Agriculture in developing countries is characterised by large numbers of such small and marginal farmers with less than 2 ha of land (Conway, 2011). The steady decline in profit from rice farming is one of the major reasons for these farmers to remain poor. High levels of production achieved from the green revolution technologies have kept the world market prices of rice low, thus affecting the livelihood of the rice farmers. Nonetheless, most of the major rice producing countries have consumer-friendly policies that keep the prices of rice stable and within the reach of the purchasing power of low income consumers, all at the cost of the producers (Mew et al., 2003).

Other major deterrents for rice production are economic growth and industrialization in major rice producing countries that have caused a reduction in the agricultural labour supply and an increase in the wage rate. It has resulted in lowering the profitability of rice cultivation. Also, continuous monocropping of rice has degraded the soil and reduced the factor productivity. These reasons act as catalysts for both the farmers and policy-makers to seek alternative income sources for the resource poor farmers. From the perspective of a developing country, government and policy-makers view the shift from paddy to high value crops as an important approach to increase the agricultural income of small and marginal farmers, increase in off farm employment opportunities, thus reducing the incidence of poverty and stimulating overall economic growth.

Among the states of India, Kerala recorded the highest degree of crop diversification among food crops (Kumar & Gupta, 2015). The wetland paddy in Kerala has been subsequently replaced by high value crops, namely, rubber and coconut (Viswanathan, 2014). The share of area under food crops reduced from 35% in 1960 to 9% of the total cropped area in 2010-11 (Andrews, 2013). This has resulted in a situation where Kerala has a food deficit of around 85% and produces only one-sixth of its total food grain requirement (Rejula & Singh, 2015). According to the state agricultural development policy report *"If the present trend [in change in land use] is allowed to continue, the state of Kerala would become the most food insecure part in the country"* (Government of Kerala, 2015). Furthermore, the report also highlights the increasing rate of farmers' distress and suicides, prominent in the regions of high commercialization and HVC cultivation. Even after focused interventions[2] of the state government, the rice production has not responded positively (Government of Kerala, 2016).

To summarize, the multidimensional challenge faced by India is achieving food security and poverty reduction, while maintaining the essential ecosystem services. Literature deliberates on the effects of cash crops on household welfare and food security in developing countries. It is important to note that these findings cannot be generalized, as the impact of cash crop adoption on households significantly varies with the countries and crops under consideration (Anderman, Remans, Wood, DeRosa, & DeFries, 2014). In this context, Pingali (2004) provides a set of agendas on which the future research needs to be oriented in order to make the process of transition from staple to commercial crops frictionless while minimizing its social and environmental consequences. Firstly, focus of research should be on providing farmers with the flexibility of crop choices instead of focusing on one or the other specific set of crops. Secondly, different strategies for diversification of income and livelihood of the rural households should be identified. Thirdly, focus should be on assisting the governments to formulate policies with a long term perspective rather than short term "crisis situation" motives. Building on these arguments, this dissertation centers on the state of Kerala in India to identify the factors influencing the crop choices of small and marginal farmers and the impact pathways of their crop choices on household welfare.

[2]These interventions include The Kerala Conservation of Paddy Land and Wetland Act (2008), an increase in the paddy cultivation per hectare assistance from ₹ 1500 to ₹ 4500, the collective farming initiative through Self Help Groups (SHGs) and an increase in the procurement price from ₹ 19 per kg to ₹ 21.50 per kg.

1.2 Research objectives

The overall objective of this dissertation is to analyse the land use dynamics of small and marginal farmers and the subsequent impacts using the case of paddy farmers in Kerala, southern India. Specific research objectives are outlined as below:

1. To examine the macro drivers (exogenous to the household) influencing land transformation from paddy farming to a market-oriented system.
2. To estimate the short-run and long-run paddy area allocation in response to temporal changes in price and non-price factors.
3. To analyse the household determinants influencing HVC adoption among agricultural households.
4. To estimate the welfare impacts of HVC adoption by small and marginal farming households.
5. To analyse the impact of methane emission taxes on paddy production.

1.3 Conceptual framework of the dissertation

Household adoption decision is a complex process that depends not only on the household preferences but also on the macroeconomic and agricultural policies, which influence the production conditions (Babu, Gajanan & Sanyal, 2014). In order to understand the dynamics of decision-making behaviour, it is essential to conceptualize the agricultural situation, its components and their interrelationships. With this view, to analyse the causes and impacts of adoption, this work uses a modified version of a conceptual framework (Figure 1.1) developed by von Braun (1995).

The framework focuses on the farm households' decision-making behaviour on HVC adoption. In order to simplify the analysis from a household perspective, this framework separates out the exogenous factors influencing decision-making from the endogenous factors. These two sets of factors act at macro and household levels, respectively. Three potential pathways that influence farmers' decision to adopt are identified. The first

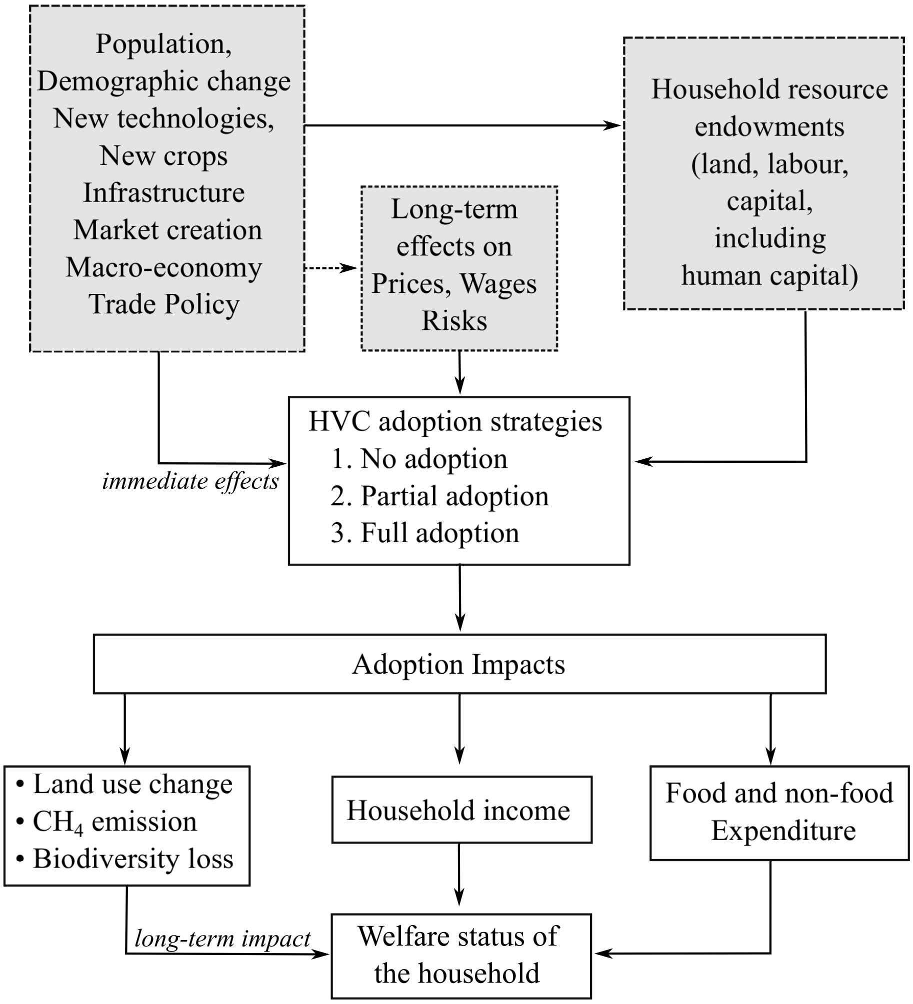

Figure 1.1 Determinants and impact pathways of farm diversification.
Source: Adapted from von Braun and Kennedy (1995).

possible pathway is the influence of the macro-level (district, state) factors, such as, agricultural policies, technological progress, population and demographic pressure, and institutional infrastructure on the adoption decision. The influence of these factors on adoption are analysed in chapter 1 of the dissertation by using district and state level data. Second pathway is the influence of long-term changes in wages, prices and risk associated with agricultural production process on the adoption decision. The adoption decision can be viewed as farmers' response to relative price signals and changes in agro-climatic conditions (Mukherjee, 2010). It is, hence, important to capture the temporal dimension of these macro drivers to clearly understand the adoption process. Chapter 2 addresses this pathway by analysing the short–run and long–run area allocation of farmers in response to the temporal changes in the price and non-price factors. The third potential pathway comprises of different micro-level determinants acting at the household level. The household resource endowments such as land, labour, and human capital and their allocation can play an important role in the crop choice decision in this respect (Babu et al., 2014).

On the impact side, two pathways are analysed. First, the household decision on the choice can have endogenous consequences on the household income and expenditure of the household (von Braun & Kennedy, 1994). Increase in household income and expenditure can improve the overall welfare status of the households. On the other hand, if the choice of crop is towards low labour-intensive farming system, the households depending on the farm labour as their major source of income will be adversely affected. The second impact pathway is concerning the environmental consequences of crop choices. This can be considered more crop management specific and depends on government policies that encourage the production of certain crops (Barbier, 1989). There can be different ways in which the choice of crop can affect the environment, for example, loss in biodiversity and soil degradation. One particular pathway, which is addressed in this dissertation, is the methane emission from rice fields. The choice of this pathway is motivated by the fact that there is lack of literature addressing the relationship between measures for mitigating methane emission from rice fields and its impacts on farmers' welfare in India. While the environmental consequences of cash crop adoption in paddy fields are well studied, e.g.

by Gopikuttan and Kurup (2004), Karunakaran (2014) and Nair and Menon (2007), the implications of methane emissions for rice fields in particular remain unexplored.

1.4 Synthesis of the thesis

The dissertation is divided into five chapters. Chapter 1 gives the general introduction to the overall dissertation and to the rest of the papers. The overview of the articles included in the dissertation is presented in Table 1.1.

Chapter 2 presents the trends and patterns in agricultural land use changes in the state of Kerala and in Wayanad district. The chapter also focuses on identifying the macro level (exogenous to the household) drivers determining the land use transformation in paddy farming. It uses data from multiple sources, which include, focus group discussions, participatory rural appraisals, and stakeholders' workshops conducted during the period of 2010-2013 coupled with state and district level data for the period 1983-2011. The analysis reveals low profitability of paddy farming, labour shortage, and demographic pressure as the major macro level causes of paddy land use change. Even though land use changes are the consequences of farmers' livelihood responses to these changing macro drivers, at a more fundamental level, it reflects the unintended policy conflicts and lack of sectoral policy integration and implementation strategies.

Farmers' crop choice responses and the magnitude of their response also depend largely on the long-term volatility in the agricultural commodity prices and climatic factors. Chapter 3 analyses this response as the impact of price and non-price factors on acreage allocation of paddy growers. It uses time series data covering the period 1987-2009 on the prices of paddy, and competing crops along with other macro variables, such as, rainfall and wages to quantify the elasticity of response of these variables to the acreage allocation of paddy in Wayanad. The chapter uses unit root testing to avoid spurious regression. Autoregressive Distributed Lag Approach (ARDL) for co-integration is used along with bounds testing to estimate the short- and long-run elasticities of paddy area allocation. The results imply that farmers respond positively to paddy price and negatively to female wage rate in the long-run as well as in the short-run. However, there was no significant impact of rainfall and the price of competing crops on the area allocation decision of the farmers.

Table 1.1 List of papers included in the dissertation

Chapter	Title of the paper	Authors	Published in/submitted to/presented at
2	Dynamics of agricultural land use change in Kerala: A policy and socio-ecological perspective	Monish Jose and Martina Padmanabhan	Published in *International Journal of Agricultural Sustainability* (2015), 14(3), pp 307-324, doi:10.1080/14735903.2015.1107338
3	Impact of price and non-price factors on paddy cultivation in Wayanad District of South India	Monish Jose and Ulrike Grote	Submitted to *Asian Economic Journal.*
			Contributed paper to 29th IAAE 2015- *"Agriculture in an interconnected world"*, Milan, Italy, August 8-14, 2015.
			Contributed paper to 21st Annual Agricultural Economic Research Association conference on *"Sustainable agricultural growth for improving rural livelihood security"*, Srinagar, India, September 10-12, 2013.
4	Assessing the household welfare impacts of cash crop adoption in wetland paddy system of southern India	Monish Jose and Ulrike Grote	Submitted to *Agricultural Economics*
5	Emission taxes as a GHG mitigation mechanism in agriculture: Effects on rice production in India	Gayatri Y.P and Monish Jose	Published in *Agriculture Economics Research Review* (2014), 27(2), pp 157-167, doi:10.5958/0974-0279.2014.00020.2
			Won the award for best research article published in *Agricultural Economics Research Review* in 2014.
			Contributed paper to the 28th IAAE 2012 Conference *"The Global Bio-economy"*, Foz Do Iguacu, Brazil, August 18-24, 2012.

Note: The contribution of the authors to the submitted articles is as follows: The data collection, literature review, all calculations and drafting the text have been done by Jose, unless noted otherwise. The contribution of Grote includes overall supervision, providing suggestions, guidance on methods and editing. The contribution of Padmanabhan in chapter 2 includes providing suggestions and editing. In chapter 5, the contribution of the authors is: Gayatri and Jose collected the secondary data, estimated the model and wrote the paper in equal shares.

Chapter 4 determines the drivers of HVC adoption among paddy farmers and their impact on the welfare of small and marginal households. It uses cross-section data collected during 2011 from 304 small and marginal households in Wayanad. Household income and expenditure are used to measure the welfare. In order to control for self-selection bias and possible endogeneity, an endogenous switching regression model is used. The welfare impacts of a heterogeneous HVC adoption decision are discussed in detail. It was found that land characteristics, such as, farm size, access to transport, number of plots and distance to farm from dwelling influence the decision-making behaviour. The results also indicate that cash crop adopters are better-off when compared to the non-adopters. The heterogeneous adoption impact reveals that the farmers who chose to partially adopt cash crops in combination with paddy have higher welfare than farmers who exclusively adopted cash crops.

Chapter 5 focuses on the impact of emission tax on paddy production of India. Emission tax as a Greenhouse Gas (GHG) mitigation mechanism can lead to an increase in the cost of production and shift from rice to other crops subsequently inducing land use change especially among smallholders. The concept of an iso-elastic supply function and a shift parameter are used to estimate the shift in supply and demand of rice production at national level. Shadow price of carbon and market price of carbon are used as hypothetical emission tax levels to estimate the shift parameter. The result indicates that emission taxes on paddy production would have negative impacts on farmers' welfare.

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Chapter 2

DYNAMICS OF AGRICULTURAL LAND USE CHANGE IN KERALA: A POLICY AND SOCIAL-ECOLOGICAL PERSPECTIVE

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Chapter **3**

IMPACT OF PRICE AND NON-PRICE FACTORS ON PADDY ACREAGE RESPONSE IN WAYANAD DISTRICT OF SOUTHERN INDIA

This chapter is a version of: Monish Jose & Ulrike Grote (2015), "Impact of price and non-price factors on paddy cultivation in Wayanad District of South India", Contributed paper to 29th IAAE conference- *"Agriculture in an interconnected world"*, Milan, Italy, 8-14 August 2015.

Abstract

Despite the efforts from the government, the land use change from wetland paddy to other cash crops and non-agricultural use is on rapid rise in Kerala. We explore the case of Wayanad in Kerala, which is home to traditional as well as geographical indicator varieties of paddy, where drastic decline in the area under paddy production is witnessed. This study attempts to estimate the impact of price and non-price factors on the acreage response of paddy farmers so that appropriate policies are formulated to promote paddy cultivation. The study uses bounds testing approach to co-integration to estimate short run and long run estimates. The results reveal that farmers respond positively to price of paddy and negatively to increase in female wage rate in both long and short run. The study recommends interventions to improve the price of paddy received by the farmers and labour reforms to improve the utilization of female labour work force in agriculture to increase area under paddy cultivation.

Keywords: Area response, paddy cultivation, co-integration, land use change.

3.1 Introduction

Agricultural land use and agricultural policy instruments play an important role in shaping the economy of developing countries as majority of the rural population depends on agriculture for their livelihood. Agricultural policies influence the farmers' decision in the allocation of resources, such as land, labour and capital, among crops. It can also influence the allocation between agricultural and non-agricultural land uses, where agricultural land has an alternative use value. The land use decisions have a significant impact on the supply of the agricultural commodities and environmental outcomes (Claassen & Tegene, 1999).The success of these agricultural policies, such as, economic incentives to the economy largely relies on the responsiveness of the farmers to such policy interventions. Acreage response can be used as an effective evaluation technique to assess the agricultural policies and land allocation changes. Reliable estimates of response function provide crucial information for the policy makers to formulate effective agricultural and land use policies or to make amendments to the existing policies in order to achieve sustainable land use systems and agricultural growth.

The performance of agriculture is critical to achieve overall economic growth in a developing country like India. Even though agricultural contribution to India's total GDP decreased from 51% in 1950's to 17% by 2014, the sector provides 50% of the total employment (Planning Commission, 2014). Recent studies show that the agriculture in India is experiencing crisis with lower growth rate and productivity (Siddiqui, 2014). As argued by Tripathi (2008) and Olayiwola (2013), even after government initiatives, such as, increase in minimum support price (MSP), improved market, irrigation and credit facilities, the literature on Indian agriculture has shown that the farmers are less responsive. Despite the success of green revolution in late 1960's and liberalization of economy in early 1990's, the response of Indian farmers remains weak (Mythili, 2008). The reason behind the lower responsiveness to policy instruments, as per Mythili (2008), could be 1) sensitiveness of the response to the nature and specification of the methods used in the previous studies. 2) ineffectiveness of existing polices to identify and target the constraints faced by the farmers. The current literature is thus inconclusive on the responsiveness of Indian agriculture as well as limited in the selection of estimation methods. According to Olayiwola (2013), there are no recent reliable estimates to see if the response has improved in India after the introduction of economic reforms in early 90's. In the light of these issues, there is a need to re-examine the responses of agricultural supply if an effective overall agricultural policy has to be implemented. Hence, the objective of this paper is to estimate the acreage response of Indian farmers by applying recent approaches in econometric literature, which are less restrictive and relatively robust than earlier used methods. Specifically, we aim at estimating the short run and long run elasticities of acreage response, by taking the example of the staple food crop, rice in the Kerala state of South India.

Tripathi (2008) gives a brief overview of the previous studies on the supply/acreage response of Indian farmers; most of which use Nerlovian restrictive adaptive expectation model or partial adjustment model (Nerlove, 1971). It is argued that the Nerlove model is limited in its abilities to capture the full dynamics of agricultural supply (Muchapondwa, 2009; Thiele, 2000). The regression results of these models can also be spurious raising doubts on the validity of the estimates (Ozkan & Karaman, 2011). Autoregressive Distributive Lag (ARDL) (Pesaran & Pesaran, 2010; Pesaran & Shin, 1998; Pesaran, Shin, & Smith, 2001) has better small sample properties and methodological advantages over previous techniques. This study uses ARDL approach to estimate supply elasticities and to contribute to the literature by improvised estimation technique over previous approaches. The details on the development and issues associated with different supply response models are discussed in section 3.4.2

Past literature addressing the farmers' responsiveness in India, by and large, used time series data aggregated at country level. This approach even though has a broader scope for policy intervention inferences,the approach fails to capture the inter-state variability and state-specific characteristics. Especially for countries with wide agro-ecological diversity, such as, India, location specific study inferences can provide better information and can advocate targeted policy interventions. In addition, the recent decentralization and local governance system of India have made the grass-root level institutions (*gram panchayats*[1] and *zilla panchayats*[2]) more powerful to exercise greater control over the implementation of rural development programs. Considering this, we explore the responsiveness of farmers using a district level data. Specifically, we focus on the Wayanad district of Kerala state

[1]Politically elected village level self-governance body
[2]District level self-governance body

in Southern India, where agricultural land use is in a stage of transition from paddy farming to non-food crops or even to non-agricultural land uses in spite of multiple revival efforts from the Government (Government of Kerala, 2016). The agricultural policies and interventions advocated without prior empirical support might produce unintended results (Muchapondwa, 2009). Our paper seeks to provide empirical evidence on the relationship between the acreage allocation decision and the price and non-price factors among the paddy farmers in Wayanad district of Kerala. Thus, this study would assist policy makers to identify the major factors that determine the acreage allocation by the farmers and to formulate effective policies to encourage paddy cultivation.

The rest of the paper is organized as follows; the next section briefs about the data and the study region followed by research framework and methodology. Then, we present the results in section three, discussion in section four and finally, the conclusion in the last section.

3.2 Previous studies on farmers' response

One of the pioneering works on the supply response of farmers from an Indian context was done by Krishna (1963) using Nerlovian adjustment model on undivided Punjab data, where they estimated the rice acreage response elasticities of 0.31 and 0.59 for short-run and long-run respectively. The importance of non-price factors in measuring the acreage response is asserted by Krishna (1963), where the author argues that the net effect of price variables can be properly measured only if the non-price variables determining supply are well specified. The argument on the importance of non-price factors was also supported by a study that followed, using distributive lag analysis (Parikh, 1971). However, most of the studies on supply response of Indian agriculture use data from pre independence to 1970's and are mainly based on the Nerlove approach or production function framework (Cummings, 1975; Herdt, 1970; Krishna, 1963; Krishna & Raychaudhuri, 1980; Lambert & Narain, 1968; Madhavan, 1972). Cummings (1975) reviewed the past studies on supply response from pre-independence to mid 1970s and ascertained a large variation in supply response elasticities across studies.

With the development of more robust time series econometric techniques, recent work on the supply response, greatly involve either auto-regressive integrated moving average (ARIMA) or a superior approach, co-integration techniques along with error correction (Hallam & Zanoli, 1993). Narayana and Parikh (1981) critiqued the Nerlove-model for specification error in the formulation of price expectation function and recommend the identification of stationary and random components in the series and used ARIMA in formulating the expectation functions.

The studies on supply response during the pre-liberalization period, with varying methodological approach show high variability in the range of estimated price elasticities of rice. Gulati and Kelley (2001) analysed supply using pooled data for 23 crop zones of India for the period 1970-1991 using pooled cross section panel data and corroborated the importance of non-price factors in explaining the shift in cropping pattern. Their analysis concluded that the paddy area was responsive to prices in only few zones with a very narrow elasticity range of 0.06-0.17. On the other hand, as compared to the earlier studies, Surekha (2005) established a larger value of 1.9 for long run elasticity using a two stage Bayesian estimator and 0.54 using ordinary least square (OLS) method for the period 1953-1986 . The authors attributed the relatively lower elasticity estimates found in many of the earlier studies to the sensitiveness of the method adopted and, developed non-linear autoregressive distributed lag model to study the supply response. Acreage response elasticity for rice estimated by Kumar and Rosegrant (1997) for the period 1970-71 to 1987-88 was low, ranging between 0.019 in the short run and 0.12 in the long run.

Studies on supply response for post liberalization era are limited (eg., Kanwar,2006; Kanwar and Sadoulet,2008; Mythili, 2008; and Tripathi and Prasad,2009). Mythili (2008) and Kanwar (2006) using Arellano-Bond estimator detected a slower adjustment for rice acreage (0.12 and 0.32 respectively). The low adjustment coefficient is attributed to the fact that farmers are reluctant in making larger adjustments for major cereals used for self-consumption. Mythili (2008) found no significant difference between the supply elasticities for rice before and after liberalization. This study also indicated that farmers increasingly respond better through non-acreage inputs than shifting the acreage. In general, post-liberalization period studies conclude that rice acreage elasticity remained low with slow area adjustment coefficient. Common conclusion which can be drawn from the past literature on farmers supply response in India are the following; low acreage response was reported in most of the studies. The reported range for both long run and short elasticities are very broad and inconclusive, the differences being attributed to the underlying method used in estimation. Vast majority of studies relied on Nerlove model and OLS estimation that are not likely to capture the full dynamics of the agriculture response.

3.3 Study location

The state of Kerala witnessed drastic reduction in area under paddy cultivation during the past few decades. Farmers replaced paddy with either cash crops or, left their land fallow for years (Raj & Azeez, 2009) for future non-agricultural use. Wayanad district, located in north-east of Kerala (Figure 3.1) also witnessed 70 percent decrease in its paddy area since 1980's. Majority of the paddy area is replaced by cash crops, such as, banana and later put to non-agricultural use. Conservation and promotion of paddy cultivation in this region is important, because Wayanad is a part of 'Western Ghats', which is one of the global biodiversity hot spots (Myers, Mittermeier, Mittermeier, da Fonseca, & Kent, 2000) and UNESCO recognized world heritage sites. According to the literature, paddy fields in Wayanad support numerous species of plants and animals of use value that also include medicinal plant species (Lockie & Carpenter, 2010). In addition, the region is very well known for traditional and special varieties of paddy. Studies show that Wayanad was home to more than 75 varieties of paddy (Girigan, Kumar, & Nambi, 2004), which include two paddy varieties that have a status of geographical indication. Even though the government has initiated several steps to promote paddy cultivation in Wayanad, the area under paddy continues to decrease.

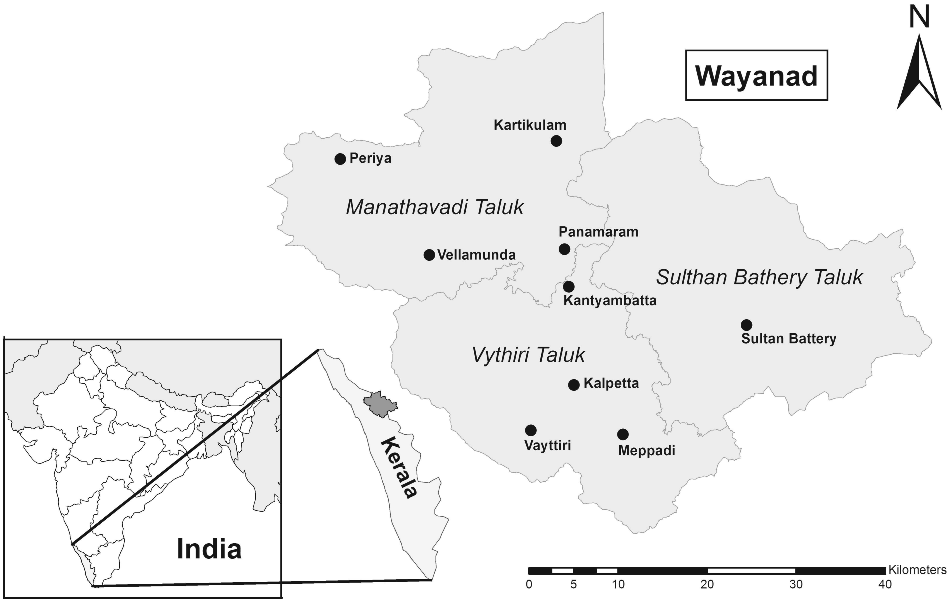

Figure 3.1 Geographical location of Wayanad district, Kerala.

3.4 Theoretical framework

3.4.1 Basic model

In the basic Nerlove framework (Nerlove, 1958) the acreage response function in log form can be written as a function of expected price,

$$Y_t^* = \beta_0 P_t^{*\beta_1}$$
$$Y_t^* = \beta_0 + \beta_1 P_t^* \tag{3.1}$$

Y_t^* is the desired cultivated area for the period t, P_t^* is the price expectations which are latent. The model can be extended with other exogenous non-price factors, such as, climatic variables and wage which are hypothesised to influence the expected area allocation.

Assuming that the price expectations are adaptive, for instance, the farmers' expectation is a function of the proportion of deviations from his or her earlier price expectation and actual price, then

$$\begin{aligned} P_t^* - P_{t-1}^* &= \delta(P_{t-1} - P_{t-1}^*) \\ P_t^* &= \delta P_{t-1} + (1-\delta)P_{t-1}^* \end{aligned} \tag{3.2}$$

where P_{t-1} is the lagged actual price for the period $t-1$, δ is the coefficient of expectations, such that $0 < \delta < 1$.

Similarly, the acreage allocation can be derived from the partial adjustment assumption, which is a proportion of change in the latent expected area and the previous allocated area to achieve the desired level of output as,

$$\begin{aligned} Y_t - Y_{t-1} &= \gamma(Y_t^* - Y_{t-1}) \\ Y_t &= \gamma Y_t^* + (1-\gamma)Y_{t-1} \end{aligned} \tag{3.3}$$

where, $0 < \gamma < 1$ is the adjustment coefficient. Substituting equation (3.1) and (3.2) in equation (3.3) gives the reduced form of acreage response function, including the other exogenous factors, Z_t as below,

$$\begin{aligned} Y_t =& \beta_0\gamma\delta + \beta_1\gamma\delta P_{t-1} + [(1-\gamma)(1-\delta)]Y_{t-1} \\ & - [(1-\delta)(1-\gamma)]Y_{t-2} + [\gamma u_t - \gamma(1-\delta)u_{t-1}] \\ Y_t =& \alpha + \alpha_1 P_{t-1} + \alpha_2 Y_{t-1} + \alpha_3 Y_{t-2} + \alpha_4 Z_t + \varepsilon_t \end{aligned} \tag{3.4}$$

which is a log transformed lag distributed estimable model. The short run elasticities are given by the coefficients (α's) of the lagged variables, where as, the long run coefficients are estimated as $\frac{\alpha_1}{1-\alpha_1}$.

3.4.2 Analytical developments

The partial adjustment model discussed above has been widely applied in agricultural supply response estimation studies, in combination with or without adaptive expectation. Later studies have criticized this approach (McKay, Morrissey, & Vaillant, 1999; Muchapondwa, 2009). It is not possible to differentiate between and when the model specification has both adaptive expectation as well as partial adjustment. This implies that unless arbitrary assumptions are imposed on the model specification, either as adaptive expectation or as partial adjustment, estimation of long run elasticity is not possible. From the estimation equation (3.4), it is clear that the model can involve both partial adjustment and adaptive expectation in the same dynamic specification. Further, as noted by McKay et al. (1999) and Thiele (2000), the theoretical assumptions used in the model are considered to be inadequate can result in downward bias in the estimated elasticities and hence the Nerlovian model cannot capture the full dynamics of the response of the farmers (Muchapondwa, 2009).

Furthermore, the OLS estimation approach used in Nerlovian-model studies, assumes that the underlying time series data is stationary. However, it has been observed that most of the agricultural time series data are non-stationary at levels. Using OLS on non-stationary data can result in spurious regression estimates (Granger & Newbold, 1974). Therefore, the studies employing the Nerlovian partial adjustment model have constantly produced low and biased estimates of the price elasticity for developing countries from different regions (Thiele, 2000). To overcome restrictive dynamic specification of the Nerlove-model, co-integration analysis, which is based on long run co-movement of the variables, can be conducted as it does not impose any restrictions on the short-run behaviour of prices and quantities. In combination with error correction model (ECM), co-integration analysis can be used to obtain consistent estimates of short and long run elasticities. The ECM with co-integration using stationary variables can overcome the problem of spurious correlations which may occur in OLS regressions of the Nerlove-model if variables are non-stationary (Thiele, 2000), and hence, is a superior alternative to partial adjustment model both theoretically and empirically (Hallam & Zanoli, 1993).

A range of co-integration approaches exist in the time series literature, such as, the most commonly used Engle and Granger (1987) method, Johansen (1991) and Johansen and Juselius (1990). All these methods have their own merits and limitations. Engel-Granger approach ignores short-run dynamics while estimating the co-integrating vector thus resulting in biased estimates of long-run coefficients especially in finite samples with complex short-run dynamics, where as the Johansen method requires large data samples for validity, strongly relies on the unit root test and assumes that the order of integration of all the variables is same and known with certainty (Muchapondwa, 2009). The Auto Regressive Distributive Lag (ARDL) co-integration approach has numerous advantages in comparison with other co-integration methods (Odhiambo, 2009; Ozturk & Acaravci, 2010). ARDL is relatively a recent approach to co-integration proposed by Pesaran and Shin (1998) and extended by Pesaran et al. (2001) using bounds testing to overcome the problems of Johansen estimation procedure and Engle-Granger procedure in co-integration techniques (Getnet, Verbeke, & Viaene, 2005). This approach tests for the existence of a non-spurious long term co-integration relationship among the variables involved. It also captures long-run equilibrium and short run dynamics for the testing co-integration relationship (Pesaran et al., 2001). ARDL method also allows the estimation of long run co-integration relationship even when the variables are I(0), I(1) or a combination of both. This approach avoids the pre-testing of unit roots using conventional unit root testing mechanism on the time series and overcomes the uncertainties of lower statistical power associated with these unit root tests (Getnet et al., 2005). ARDL approach is efficient even when the sample size is small while other co-integration techniques are sensitive to the size of the sample (Odhiambo, 2009). This approach allows different optimal lag length for different variables as opposed to same lag length in Johansen's method. This method is also less sensitive to endogenous regressors in the model and generally provides unbiased long run estimates (Odhiambo, 2009). Previous studies using bounds testing ARDL model for supply response include Muchapondwa (2009), Binuomote, Ajetomobi, and Omodunbi (2012), Boansi (2014), Ogundari (2016) and Getnet et al. (2005).

3.5 Methodology

3.5.1 Data

The data for estimating the acreage response of Wayanad farmers is compiled from publications, such as, Agricultural Statistics and Statistics for Planning, published by Directorate of Economics and Statistics, Kerala. The district of Wayanad was administratively formed in 1980, but consistent and regular data on variables, such as, area and prices from Wayanad is only available from 1987. Hence, a time period of 1987-2009 is selected for the study.

The choice of appropriate dependent variable to measure supply response is often debated in supply response literature (Narayana & Parikh, 1981) and is inconclusive among price, output or area. Mythili (2008) argues that output is subject to more fluctuation than area because of uncertain random factors, namely, temperature and rainfall, and area is a more appropriate variable especially when response is confined to changes in area allocation than total area under cultivation. Hence, we use absolute paddy area of winter (LPA) in hectare for this study. Other studies using area to measure response include Lambert and Narain (1968) and Krishna (1963). The variables used in the study are price of paddy (LPP) in Rupees/quintal, price of banana (LBP) in Rupees/quintal, female wage rate of agricultural workers (LFW) in Rupees/day of Wayanad district. Price and wage data are deflated to 2010 real prices using the WPI (Wholesale Price Index) for agricultural commodities to account for inflation. The importance of rainfall as a relevant variable in determining the supply response is supported by several studies (Narayana & Parikh, 1981; Imai, Gaiha, & Thapa, 2011; Kanwar, 2006; Mythili, 2008; Tripathi & Prasad, 2009). The data on rainfall of Wayanad was extracted from western grid rainfall data from Indian meteorological department. Rainfall as a weather parameter is difficult to incorporate in the analysis, because, average total rainfall in a crop season, rainfall in the pre-sowing period and absolute deviation from normal rainfall can have different impacts on the paddy cultivation. According to Mythili (2008), there is no satisfactory measure of rainfall in the area or supply response literature. However, the current study uses the average daily rainfall in mm (LRF) for the months of May, June, July and August as they include the pre-monsoon and monsoon season, which coincides with the land preparation, sowing and transplanting of paddy in Wayanad. Therefore, rainfall during these months is more likely to have an influence on the area allocation. All the variables are converted to their natural logarithms for the empirical analysis.

3.5.2 Empirical estimation

Empirical estimation of ARDL modelling technique to co-integration consists of four steps: 1) unit root testing for identifying the right order of integration of variables involved; 2) establishing the existence of long run co-integration relationship among the variables using bounds testing; 3) estimation of the ARDL model to obtain short run and long run coefficients; finally, testing the stability of the model and the coefficients using various diagnostic tests. In the next few paragraphs we will be covering these steps in detail.

The hypothesized functional relationship between acreage allocation and the dependent variables are modelled as,

$$pa_t = \alpha_0 + \alpha_1 pp_t + \alpha_2 bp_t + \alpha_3 fw_t + \alpha_4 rf_t + v_t \tag{3.5}$$

Before testing the model for co-integration, the order of integration of individual variables are tested using conventional Augmented Dickey-fuller (ADF) and Philips-Perron (PP) test. Unit root tests are conducted to ensure that the variables are integrated of order less than two (Abbott, Darnell, & Evans, 2001) as the ARDL approach requires the integration of the variables I(0), I(0) or a mix of both. PP unit root test is also conducted due to its robustness to auto-correlation as it allows the presence of unknown forms of correlation in time series and conditional heteroscedasticity in the error term (Muchapondwa, 2009). The optimal lags for the ADF tests are selected based on Schwarz's Bayesian Information Criterion (SBIC). The ADRL modeling approach involves the estimation of the following unrestricted (conditional) error correction model (UEC) by ordinary least square method in order to test for one or more co-integration relationships among the variables:

$$\begin{aligned}\Delta pa_t =& \beta_0 + \sum_{i=1}^{p} \beta_{1i} \Delta pa_{t-i} + \sum_{i=0}^{q_1} \beta_{2i} \Delta pp_{t-i} + \sum_{i=0}^{q_2} \beta_{3i} \Delta bp_{t-i} + \sum_{i=0}^{q_3} \beta_{4i} \Delta fw_{t-i} \\ &+ \sum_{i=0}^{q_4} \beta_{5i} \Delta rf_{t-i} + \gamma_0 pa_{t-1} + \gamma_1 pp_{t-1} + \gamma_2 bp_{t-1} + \gamma_3 fw_{t-1} + \gamma_4 rf_{t-1} + \varepsilon_t \end{aligned} \tag{3.6}$$

where Δ is the difference operator, ε_{it} is the white noise error term and other variables as defined earlier. After the estimation of the above model the presence of co-integration can be tested using the bounds testing approach. Accordingly, in order to test the long run relationship among the variables, *F-test* is conducted for testing the joint significance of coefficients of the lagged levels of the variables with the null hypothesis that they are jointly equal to zero.

i.e,

$$\mathrm{H}_0 : \gamma_0 = \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = 0$$

as against the alternative hypothesis;

$$H_A : \gamma_0 \neq \gamma_1 \neq \gamma_2 \neq \gamma_3 \neq \gamma_4 \neq 0$$

A pair of asymptotic critical value bounds for the *F-statistic* is generated by Pesaran et al. (2001), where the independent variables are I(d). The lower bound corresponds to a situation when the regressor variables are I(0) and a upper bound value corresponding to situation when the regressors are I(1). If the calculated *F-statistic* is outside these critical boundaries, a conclusion regarding co-integration of the regressors can be derived regardless of the degree of integration of the regressors. If the computed F-statistic is lower than the lower bound value, then there is no long run co-integrating relationship among the variables, thus accepting the hypothesis. On the contrary, if it lies above the upper bound critical value, the hypothesis of non-existence of co-integrating relationship can be safely rejected. But, if the *F-statistic* lie within the bounds of the critical values then the results are inconclusive.

In the next step, once when a co-integration relationship is established, a conditional *ARDL (m, n, o, p, q)* long run model is specified of the following form;

$$\begin{aligned} pa_t = \alpha_0 + \sum_{i=1}^{m} \beta_{1i} pa_{t-i} + \sum_{i=0}^{n} \beta_{2i} pp_{t-i} + \sum_{i=0}^{o} \beta_{3i} fw_{t-i} + \sum_{i=0}^{p} \beta_{4i} bp_{t-i} \\ + \sum_{i=0}^{q} \beta_{5i} rf_{t-i} + \varepsilon_t \end{aligned} \tag{3.7}$$

where, all the variables are defined earlier. The lag length in the ARDL is selected based on SBIC selection criteria. In the third step, the short run dynamic elasticities are estimated by using the error correction model (ECM), as described below,

$$\begin{aligned} \Delta pa_t = \delta_0 + \sum_{i=1}^{m} \delta_{1i} \Delta pa_{t-i} + \sum_{i=0}^{n} \delta_{2i} \Delta pp_{t-i} + \sum_{i=0}^{o} \delta_{3i} \Delta fw_{t-i} + \sum_{i=0}^{p} \delta_{4i} \Delta bp_{t-i} \\ + \sum_{i=0}^{q} \delta_{5i} \Delta rf_{t-i} + \lambda ECM_{t-1} + \mu_t \end{aligned} \tag{3.8}$$

where, δ's are the short run dynamic coefficients (elasticities) of the model's convergence to long run equilibrium of equation (3.7) and λ is the error correction coefficient which shows the speed of adjustment to reach the equilibrium. ECM is the one period lagged error correction term derived from the long run equilibrium of equation (3.7).

The final stage involves the testing of the model defined earlier for stability and validity. A series of diagnostic tests are conducted to show the correctness of the ARDL-ECM model. Modified Lagrange Multiplier test or LMF test, which is more robust to small sample, is conducted for serial correlation (Pesaran & Pesaran, 2010). Ramsey Regression Equation Specification Error Test (RESET) is used to test the specification of the functional form of the model, Jarque-Bera test for normality and goodness of fit of the variables, LM test for hetroscedasticity and finally CUSUM (cumulative sum of recursive residuals) and CUSUMSQ (cumulative sum of squared recursive residuals) are plotted to check for the stability of the ARDL- ECM model. As the error correction term and the short run dynamics rely on the stability of the long run coefficients, these plots test for the stability of long run estimates together with the short-run dynamics, characterizing departures from the long run relationship (Dritsakis, 2011).

3.6 Results

In this section, ARDL modelling approach is applied to the underlying data to test for co-integration and estimation of long and short run dynamics of the system. As a prerequisite, to determine the order of integration of the variables, ADF and PP unit root tests are applied. An unrestricted intercept and no trend model were used for testing the presence of unit roots. Lag lengths for the ADF tests were determined by using SBIC information criteria while the lag lengths were determined based on Newey-West method for PP test. Tests were conducted for each variable at their levels and at the first difference and their results are presented in Table 3.1. Both the tests give similar conclusion regarding the order of integration of the variables. The results indicate that all the variables except rainfall are integrated of order one. Thus, the variables are a mixture of I(0) and I(1) series. A combination of variables with different lag length cannot be used with Johansen

Table 3.1 Unit root test results (ADF and PP)

Variable	ADF Z(t) (level)	ADF Z(t) (first difference)	conclusion	PP Z(t) (level)	PP Z(t) (first difference)	conclusion
LPA	−2.232	-4.36***	I(1)	−2.297	-5.81***	I(1)
LPP	−0.974	-4.11***	I(1)	−1.895	-3.78***	I(1)
LBP	−1.357	-4.11***	I(1)	−2.331	-7.90***	I(1)
LWR	0.074	-2.93**	I(1)	0.034	-4.31***	I(1)
LRF	−2.933**	-3.01**	I(0)	−3.80**	-8.68***	I(0)

Note: **, and *** indicate significance at 5% and 1% respectively. Critical values are finite sample values from MacKinnon (2010).
Source: Own computation.

procedure of co-integration. Hence the use of ARDL modelling technique which permits I(d), $0 \leq d \leq 1$, is justified in this context.

ARDL bound testing was then employed to investigate the existence of long run equilibrium relationship among the variables based on equation (3.6). Optimal lag length was selected based on the SBIC criteria for the conditional ARDL-ECM model. Accordingly, the results of Pesaran bound testing reported in Table 3.2 reveal the rejection of null hypothesis of no co-integration relationships among lagged levels of variables. The computed *F-statistic*, 4.33, is greater than the upper bound critical bound values at 5% significance levels indicating that there is a long run equilibrium relationship. According to Narayan (2005), the critical values given by Pesaran et al. (2001) are generated for large samples and can be inappropriate to use in small samples cases. Narayan (2005), hence, generated the critical values for small samples, which was also compared against the computed F-statistic.

The test result in Table 3.2 also rejects the null hypothesis of no co-integrating relationship at 10% level of significance. Therefore, the bound testing established the long run co-integration among paddy area, paddy price, banana price, female wage rate and rainfall when paddy area is the dependent variable.

After establishing co-integration in the model, OLS and ECM were used to estimate the long run and short run coefficients. The results of the estimation are presented in Table 3.3.

The LM test for serial autocorrelation in not significant and rejects the evidence of auto correlation in the model. RESET test of model functional form also shows the

Table 3.2 Bounds testing for co-integration

F_c-Statistic (F_c (LPA/LPP,LBP,LFW,LRF) K=5)			4.3268
Critical values	Sig. level	Lower Bound I(0)	Upper Bound I(1)
Narayan (2005)	1%	4.537	6.37
	5%	3.125	4.608
	10%	2.578	3.858*
Pesaran (2001)	1%	3.41	4.68
	5%	2.62	3.79**
	10%	2.26	3.35

Case III: unrestricted intercept and no trend.

Table 3.3 Estimated ECM coefficients and long-run coefficients using ARDL model

Short-run coefficients Dependent variable: ΔLPA			Long-run coefficients LPA		
Regressor	coefficient	Std. Error	Regressor	coefficients	Std. Error
Δ LPP	0.45**	0.19	LPP	0.66***	0.22
ΔLFW	−0.35*	0.18	LFW	−0.51***	0.17
ΔLBP	−0.04	0.17	LBP	−0.06	0.25
ΔLRF	0.03	0.12	LRF	0.30	0.24
δ_0	4.77**	1.99	α_0	7.06***	2.33
ecm(-1)	−0.68***	0.18			
Diagnostics					
R^2	0.62				0.93
χ^2 SC (LM F for serial autocorrelation)					2.51(0.14)
Ramsey's RESET test for functional form					0.15(0.70)
Normality (Jarque-Bera) test					0.66(0.72)
Heteroscedasticity					0.08(0.78)
$ecm = LPA - 0.66LPP + 0.51LFW + 0.06LBP - 0.30LRF - 7.06$					

Note: *, **, and *** indicate significance at 10%, 5% and 1% levels respectively. Values in parenthesis are the probability values.

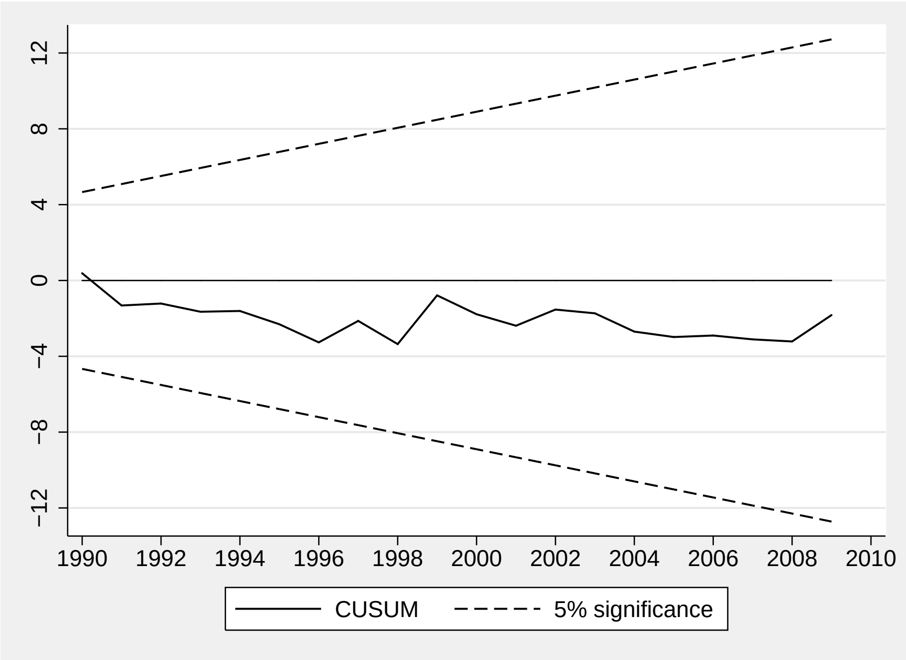

Figure 3.2 Cumulative sum of recursive residuals plot. Dotted lines represent critical bounds at 5% significant level.

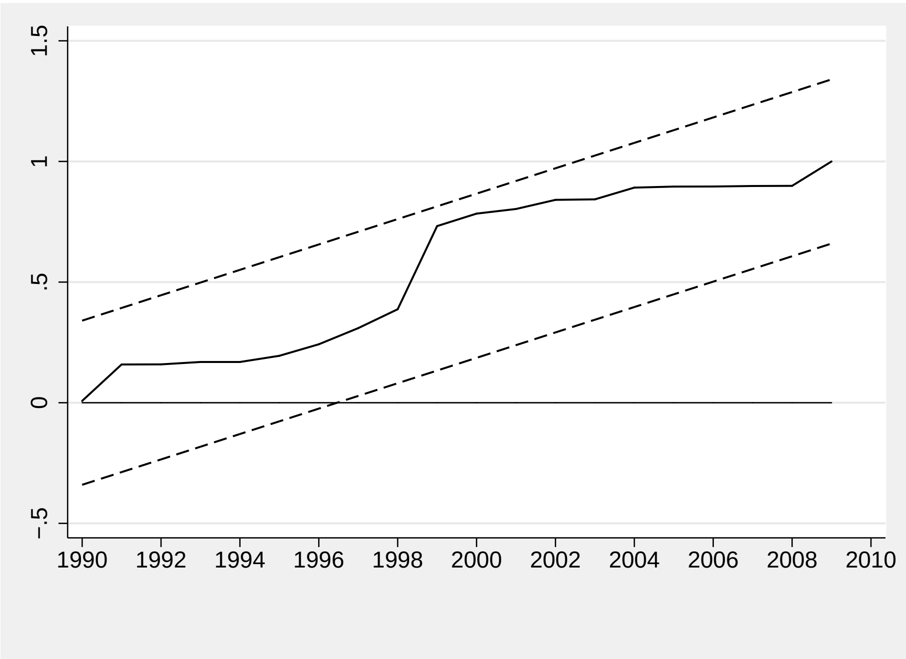

Figure 3.3 Cumulative sum of squares of recursive residuals plot. Dotted lines represent critical bounds at 5% significant level.

correctness of the model form specification. Jarque-Bera statistics for the test of normality in the distribution of the errors show that the errors are normally distributed. Test for heteroscedasticity in the error process of the model is also statistically insignificant. R^2 values explain about 93% of the variations in the long run equation and 62% of the variation in the short run equation suggesting the goodness of fit of the model. Finally, the CUSUM and CUSUM of squares of residuals are plotted and the result shows that the plot remains within the 5% statistical significance boundary (Figure 3.2 and Figure 3.3). It can be concluded from the various tests mentioned above that the model is well formulated and estimated. It also confirms the statistical stability of the estimated coefficients for a valid policy discussion.

All estimated coefficients in the error correction model have their expected sign. The negative coefficient of the error correction term is in the range of -1 and 0 and is significant at 1% level. This again supports the co-integration and the long term equilibrium relationship between the dependent and independent variables in the model (Getnet et al., 2005). Coefficient of the error correction term (-0.68) indicates high speed of adjustment towards long run equilibrium as 68% of the deviation in previous period paddy area from the long run equilibrium is corrected in the current period. In short run, the coefficients of both paddy price and female wage rate are statistically significant.

In the short run, price of paddy influences the allocation of paddy area positively, whereas female wage rate has a negative impact. The most important limiting factor for agriculture, rainfall, though insignificant has a positive sign and holds a direct relationship with paddy acreage in the long run as well as in the short run. Similarly, price of banana, which is considered as the main competing crop for paddy in Wayanad has a negative coefficient even though statistically insignificant in the long and short run.

3.7 Discussion and policy implications

When interpreting the results of acreage responsiveness of farmers, we have to consider land as a resource that is virtually fixed in total quantity at any point in time (Shi, Phipps, & Colyer, 1997). Conventionally, agricultural land is considered as a fixed resource in short run but as a variable resource in long run (Raju & Rao, 1990). Field experience from

Wayanad show that farmers cultivate banana and ginger as a rotation or alternative crop in paddy fields (Kunze, Betz, Parameswaran, & Suma, 2011). This explains the changes in area allocation of paddy in the short run as well as in the long run.

Mythili (2008) compared the price responsiveness to paddy acreage in India from various studies and reported that the price elasticity estimates for rice range from 0.06 to 0.12 in the short run and from 0.15 to 0.93 in the long run. The deviation of the price response estimates in the current study, from the past studies can be attributed to the difference in the time period considered for the analysis, difference in estimation technique used and also the location specificity of the current study. The high sensitiveness of estimates to the estimation techniques is also confirmed by previous studies (Surekha, 2005). Our finding of area equations supports the argument that the farmers of Wayanad are moderately and highly responsive to paddy price changes in the short run and long run respectively. As a result, measures on price reforms might prove effective in promoting paddy cultivation in the district. It is also advisable for the government to intervene with formal market interventions, such as, government procurement centres for paddy with a guaranteed better price for the producer. Promoting development of markets for special and local varieties of paddy from Wayanad might prove effective so that the farmers can realize higher price for these varieties.

High acreage responsiveness of paddy to female wage rate in the long and short run in the current study can be explained by the following; 1) The female labour requirement in paddy is about 70% of the total labour (Narayanan, 2006); 2) Labour contribution to the operational cost of paddy cultivation in Kerala is 60% (DES, 2012); 3) Kerala has the highest average daily wage rate in all agricultural operations throughout the year when compared to the all India average wage rate. Female labour force, hence, form an important factor in the land allocation decision of paddy, thus adding strength to the result of female labour wage rate being a major factor in the paddy acreage response. Women participation in MGNREGA[3] scheme in the district was about 84% during the year 2010-11, which has considerably influenced the agricultural labour supply. Thadathil & Mohandas (2012) indicated an increase in the agricultural wage rate due to the MGNREGA scheme in the

[3]MGNREGA stands for Mahatma Gandhi National Rural Employment Guarantee Act, 2005, which guarantee the right to work in rural area by providing 100 days of volunteer wage employment in every financial year to all adult citizens.

district, where the wage fixed by the MGNREGA serves as the unofficial minimum wage rate for agriculture.

According to our results, the increase in wage rate would have a long and short term negative impact on the paddy area cultivated in Wayanad. Further, discussions with the farmers in Wayanad revealed that MGNREGA, if, extended to the paddy field could be very effective in reducing the labour cost involved in the cultivation of paddy. The finding, high negative responsiveness of paddy acreages to female wage rates, of this study supports reforms to include paddy cultivation under the purview of MGNREGA work force so that it would facilitate in the improvement of the area under of paddy cultivation in Wayanad district of Kerala. Our results hence imply the importance of intervention to remove the constraints of labour supply to agriculture in order to strengthen the area response of paddy. The results also necessitate the need for labour cost reduction initiatives, such as, adequate investment support for farm mechanization that are suitable for smallholders in order to improve the paddy acreage response.

3.8 Conclusion

We estimated the area allocation response of farmers in Wayanad district of Kerala in Southern India. Considering the methodological issues in the earlier literature, ARDL approach of co-integration using bounds testing and error correction technique were employed. The short-run and long-run relationship between the area allocated by the farmers and various price and non-price factors was estimated. Price of paddy and price of competing crop (banana) as the price factors, rainfall as a non-price factor and wage rate as an input factor, were used in estimating the acreage response.

The results of the analysis suggest that relative to the non-price factors, price factors and input factors play a major role in determining the acreage allocation to paddy. The estimated short run and long run coefficients indicate that the acreage response of paddy towards paddy price is positive and significant. Hence, agricultural price reforms in paddy sector can promote cultivation of paddy in Wayanad. Market interventions like formal market infrastructure and direct procurement mechanism that can improve the price received by the producer are also recommended. Developing local markets for special and paddy varieties from Wayanad might improve the acreage response of paddy. The potential for labelling these varieties to assure a premium price needs to be further studied. The responsiveness of farmers towards female wage rate in the long run and short run suggests reforms in existing labour policies like MGNREGA favouring paddy farmers. Initiatives on farm mechanization that are labour saving are also suggested to improve the paddy acreage response in Wayanad.

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Chapter **4**

Assessing the household welfare impacts of high value crop adoption in a wetland paddy system of southern India

Abstract

The impact of High Value Crop (HVC) adoption on smallholders' welfare remains unexplored especially in climate vulnerable and less resilient areas. The study aims to examine the heterogeneous impacts of HVC adoption on household welfare in the ecologically sensitive and biodiversity rich Western Ghats region of South India. We use data of 303 small and marginal farming households having either fully, partly or not adopted HVCs. Per capita annual consumption expenditure and income are chosen as measures of welfare status of the households. Multinomial logit regression reveal that land characteristics, such as, farm size, access to transport, number of plots and distance to farm from dwelling influences the HVC adoption decision of the household. The results of the multinomial endogenous switching regression approach suggest that adoption has a positive and significant impact on the welfare of smallholder households but partial adopters are found to be better-off than full adopters and non-adopters.

Keywords: commercialization, impact assessment, multinomial switching regression, Kerala.

4.1 Introduction

Over the past four decades, agriculture in developing countries has experienced gradual transition from subsistence to an input intensive commercial system (Altieri & Nicholis, 2005). Globalization, rapid urbanization and accelerating pace of technological progress have increased the agro-export competition in the international market (Hall, Dixon, Gibbon, & Gulliver, 2001). The pressure on the small landholders to increase their per unit value of output has subsequently resulted in shifting the focus of production systems from food crops to high value crops (HVC) (Pingali, 1997). Policy-makers promote HVC adoption as a general strategy to move the small and marginal landholders out of poverty. Also agencies, such as, the World Bank or the Department for International Development (DFID) identified it as an important source of poverty reduction and a tool to reverse the declining investment trend in agriculture (Babu, Gajanan, & Sanyal, 2014; Pingali, 1997).

In India, policy-makers actively discuss HVC promotion (Birthal, Roy, & Negi, 2015) and encourage its use through their agricultural policies[1] (Birthal, Joshi, Roy, & Thorat, 2013). The reason for this is the pro-poor nature of the HVCs and the overwhelming number of smallholders in the country. Small and marginal farmers with less than 2 ha occupying 85% of total operational holdings dominate the agricultural sector in India (Ministry of Agriculture, 2015). Among the smallholders, HVC cultivation is considered to enhance farm income, increase employment opportunities and reduce the incidence of poverty (Birthal et al., 2013; Joshi, Joshi, & Birthal, 2006). On the consumption side, the demand for HVCs, such as, fruits and vegetables in the country is expected to increase threefold by 2030 (Birthal et al., 2015). As a result, India has seen an increase in area under HVC as well as share of HVC in total value of agricultural output (Kumar & Gupta, 2015; Rada, 2016).

However, the transition process from food crops to commercial crops is not a frictionless process and has significant environmental consequences (Pingali & Rosegrant, 1995). Commercial crop adoption can lead to unsustainable land use changes and loss in biodiversity leading to significant alteration in the environment and its natural resources

[1] For example, the Mission for Integration Development of Horticulture was launched in 2015 by the Ministry of Agriculture and Farmers' Welfare, Government of India with a mandate of promoting production and processing of fruits and vegetables (http://midh.gov.in).

(Aragona & Orr, 2011; Barbier, 1989; Garcia-Yi, 2014; Matson, Parton, Power, & Swift, 1997; Su, Yang, Hu, Luo, & Wang, 2014). In developing countries, the livelihoods of low income rural households depend on the environmental resources and services (Nguyen, Do, Bühler, Hartje, & Grote, 2015). Degradation of this environmental resource base might subsequently reduce the household welfare of smallholders by making them vulnerable to climate risks and food insecurity (King, Siddick, Gopi, & Kav, 2014). Evidence from marginalized and climate vulnerable areas shows that the households which adopted improved technology can have lower welfare than the non-adopters (Coromaldi, Pallante, & Savastano, 2015). In the South Indian state of Kerala, the adoption of high value crops over paddy, the staple food, has resulted in a decline in the ratio of food crop to non-food crop from 64:36 in 1960-61 to 13:87 in 2013-14 (Government of Kerala, 2015). This has posed a serious threat to the food security of the state and exacerbated the loss of biodiversity and local rice cultivars, soil erosion, crop pests and diseases resulting in the reduction in agricultural productivity posing indebtedness, climate and food security risks (Karunakaran, 2014; Kennedy & King, 2014; Rejula & Singh, 2015; Shanavas, Sumesh, & Haris, 2016). HVC adoption is also found to have a positive correlation with the increasing rates of suicides among marginal farmers in Kerala (J. George & Krishnaprasad, 2006; Kennedy & King, 2014).

This empirical evidence clearly indicates that even though HVC adoption among smallholders is primarily considered welfare enhancing, the results cannot be generalized. Therefore, there exist ambiguities regarding HVC adoption behavior and its impact. This leads us to some issues, which need to be further explored. Firstly, HVC adoption and its impacts on the household welfare are location-specific that depend on the production and ecological conditions and the socio-economic state of the households. Therefore, it is important to garner more micro-level empirical evidence on the adoption behaviour of the farmers especially from less resilient, climate vulnerable and biodiversity rich areas. Secondly, to meet the future climatic and food requirement challenges, it is necessary to make agriculture more productive, stable and resilient while minimizing the environmental impacts (Bommarco, Kleijn, & Potts, 2013). Hence, there is a need to focus on how the welfare benefits can be maximized while minimizing the negative social and environmental impacts so that an ecologically and socially sustainable agricultural land use system can be developed (Banik, Edmonds, & Fuwa, 2014).

To understand the relationship between welfare and adoption, we examine the case of a marginalized and climate vulnerable region in the biodiversity rich Western Ghats, namely Wayanad in Kerala, South India. Specifically, we i) identify the determinants of HVC adoption at the household level, and ii) analyse the smallholders' welfare impacts of HVC adoption. The study provides useful information to policy-makers to design effective regional and crop-specific agro-environmental programs that can safeguard the livelihood interests of small and marginal farmers while maintaining the environmental balance.

Our paper is also an attempt to augment the emerging body of literature, addressing adoption not only as a binary decision but also as a polychotomous one. Econometrically, evaluating the impact of adoption on household welfare poses the challenge of a self-selection bias (Asfaw, Shiferaw, Simtowe, & Lipper, 2012). We control for selection bias and estimate separate welfare functions that allow us to assess the heterogeneous impacts of the HVC adoption process using the multinomial endogenous switching regression approach. To our best knowledge, there is hardly any study that aims at establishing a strong empirical link between HVC adoption and its impact on household welfare in highly agro-biodiverse zones. Finally, there is a dearth of literature on robust impact assessments of HVC adoption in India. Most of the existing empirical studies use farm cost-benefit analyses and descriptive analyses to evaluate the impacts of adoption.

The paper is organized as follows; the next section provides a brief literature review followed by the conceptual framework for this research. Section 3 describes the study area, the data and the analytical methods used. Section 4 presents and discusses the results. Section 5 concludes and highlights some implications.

4.2 Literature review and conceptual framework

4.2.1 Determinants of adoption

What influences the decision-making behaviour of farmers to adopt new crops or technologies? This question has been long debated in the literature. The most comprehensive and established review on the adoption of agricultural technologies in developing countries by Feder and Umali (1993) identifies two broad perspectives of viewing determinants of adoptions: one at the household or micro-level, and one at the macro level.

From a macro perspective, adoption is influenced by infrastructure, policy framework and demographic changes. There is an overall consensus over the macro factors such as, government policy in addressing adoption and commercialization. For instance, appropriate policies facilitate the households to overcome constraints in adoption such as, lack of credit access, market information and rural infrastructure while assuring the food security needs and reducing the possible environmental consequences (Feder, Just, & Zilberman, 1985; Pingali & Rosegrant, 1995).

From a micro perspective, the individual and farm specific characteristics influence the farmers' individual decision of adoption. At the household level, these can be categorized as 1) biophysical factors (farm and soil characteristics, irrigation), 2) economic factors (land, labor, capital and other household endowments, such as, non-farm income and asset ownership), 3) social factors (group membership, access to information and cultural values) and 4) cognitive factors (environmental preferences, risk preferences, and weather perceptions) (Jain, Naeem, Orlove, Modi, & DeFries, 2015).

However, conflicting conclusions on the various micro level determinants and their influence on adoption decisions emerge from studies on adoption in India. For example, Sharma and Singh (2015) studied the adoption of modern agricultural technologies by farm households and indicated that farm size is an important positive factor in determining the adoption. Results from Birthal et al. (2013) on high value fruits and vegetable diversification indicate a negative relationship between farm size and adoption. However, Matuschke and Qaim (2009), in their study on adoption of improved hybrid wheat varieties, concluded that farm size has no significant influence on the probability of adoption.

It is also crucial to consider the heterogeneity in farmers' adoption decisions while examining the factors influencing adoption. Most earlier studies modeled farmers' decisions as a binary choice between adoption and non-adoption (Asfaw, Shiferaw, et al., 2012; Khonje, Manda, Alene, & Kassie, 2015). However, adoption in agriculture cannot be adequately represented by a dichotomous choice variable (Feder & Umali, 1993); instead, it is often considered as a sequential process. The farmers may adopt a certain HVC first on a small part of their land before further expanding (Smale, 2005). They may assume that temporal profits from adoption increase as more experience is gained (Sunding & Zilberman, 2001). Interestingly, in Wayanad, the majority of households remain partial adopters of HVCs. Results from past studies in Kerala show that HVC adoption on rice fields have posed challenges to the environment and soil fertility resulting in the reduction of agricultural production (Abdussalam, Aslam, Jyothi, Azeez, & Girijan, 2011; Karunakaran, 2014). Thus, farmers tend to examine the expected profit before taking up partial or full adoption. Therefore, it is logical to assume that the partial and full adopters might have intrinsic differences in their characteristics and preferences, subsequently having different production functions. As a result, partial adoption must be treated as a separate adoption strategy and separate welfare outcomes need to be estimated for non-adopters, partial adopters and full adopters.

4.2.2 Impacts of adoption

A decent level of research attempts to understand the relationship between adoption and household welfare. Most of the related literature exists for African agriculture. These studies show that the adoption of new crop varieties have a positive impact on household welfare and reduce the incidence of poverty. Amare, Asfaw, and Shiferaw (2012) demonstrated that maize and pigeon pea adoption in Tanzania have a positive and significant impact on income and consumption expenditure. Shiferaw, Kassie, Jaleta, and Yirga (2014) found that adoption increase food security and food consumption expenditure among Ethiopian farmers. Likewise, Kassie, Shiferaw, and Muricho (2011) from Uganda, (Asfaw, Kassie, Simtowe, & Lipper, 2012) from rural Tanzania and Kabunga, Dubois, and Qaim (2014) from Kenya studied farmers' adoption and found a similar positive relationship between adoption and household welfare. Evidence from India also suggested a strong positive link between adoption of HVC and poverty reduction (Birthal et al., 2015). Sharma and Singh (2015) followed suit to conclude that agricultural technology adoption has a significant positive impact on the consumption expenditure. However, Coromaldi et al. (2015) studied the impact of adoption on welfare and biodiversity in marginalized and climatic vulnerable areas in Uganda. Their study in one of the global biodiversity hotspots supporting rich land races, reported that the income and per capita food expenditure of adopters of modern varieties would have been higher if they had not adopted.

Effective policy interventions to promote smooth transition from food crops to commercial crops require more micro level evidence on adoption (Feder & Umali, 1993). The majority of studies assessing the impact of HVC adoption in Kerala focus on the regional magnitude of the area decline under food crops due to HVC adoption (Rejula & Singh, 2015; Shaharban & Shabana, 2015). These studies reveal an increasing trend of HVC adoption and a shift from food crops to non-food crops. However, they provide limited evidence on the households' adoption behaviour and its welfare impacts. Similarly, other available literature is confined to the macro level analysis of shifts in land use due to HVC adoption. For instance, P. S. George and Chattopadhyay (2001) studied the exogenous factors influencing land use change from a policy perspective and indicated that taxation policies and poor policy enforcement are the major determinants. Spatial analysis conducted in Wayanad report that the adoption of HVC has a detrimental impact on the traditional land use practices and calls for a multi-level transdisciplinary approach to understand agricultural transformation (Nagabhatla et al., 2015). While the environmental externalities associated with the adoption induced land use changes are well researched (Abdussalam et al., 2011; Gopikuttan & Kurup, 2004; Karunakaran, 2014; Nadesapanicker, Gopi, & Parameswaran, 2011), the household welfare impacts and socio-economic implications remain unexplored.

4.2.3 Conceptual framework

Smale, Just, and Leathers (1994) summarize the different theories put forward to explain the incomplete adoption of an agricultural technology; these relate to input rationing, risk and uncertainty, market imperfections and farmers' learning. In a developing country context, combinations of these theoretical explanations rather than a single explanation that can best explain the farmers' adoption behaviour (Smale et al., 1994). Thus, on the one hand, a risk averse farmer may choose to grow both a food crop and an HVC whereas a risk neutral farmer may grow only HVCs. Likewise, a migrant farmer who is better skilled in growing HVCs may choose to allocate more area to HVCs than to paddy. On the other hand, an indigenous farmer who is traditionally and culturally attached to paddy farming may initially allocate less area to learn and experiment with an HVC. The choice of the farmer is also constrained by the supply of inputs such as credit, land, and labour. For instance, in paddy farming, the cost of labour accounts for approximately 70% of the total operational cost[2]. Therefore, the adoption and area allocation decision also largely depends on the availability of labour and imperfections in the rural labour market. In our case, the choice of adoption strategy varies with the socio-demographic characteristics of the farm households, and various forms of market imperfections. In such situations, it is advisable to employ a general model, which nests individual theoretical approaches to describe the adoption behaviour since it can test the competing explanations (Becerril & Abdulai, 2010). Considering this, we use a framework that captures the heterogeneity in adoption decisions of the farmers (4.1).

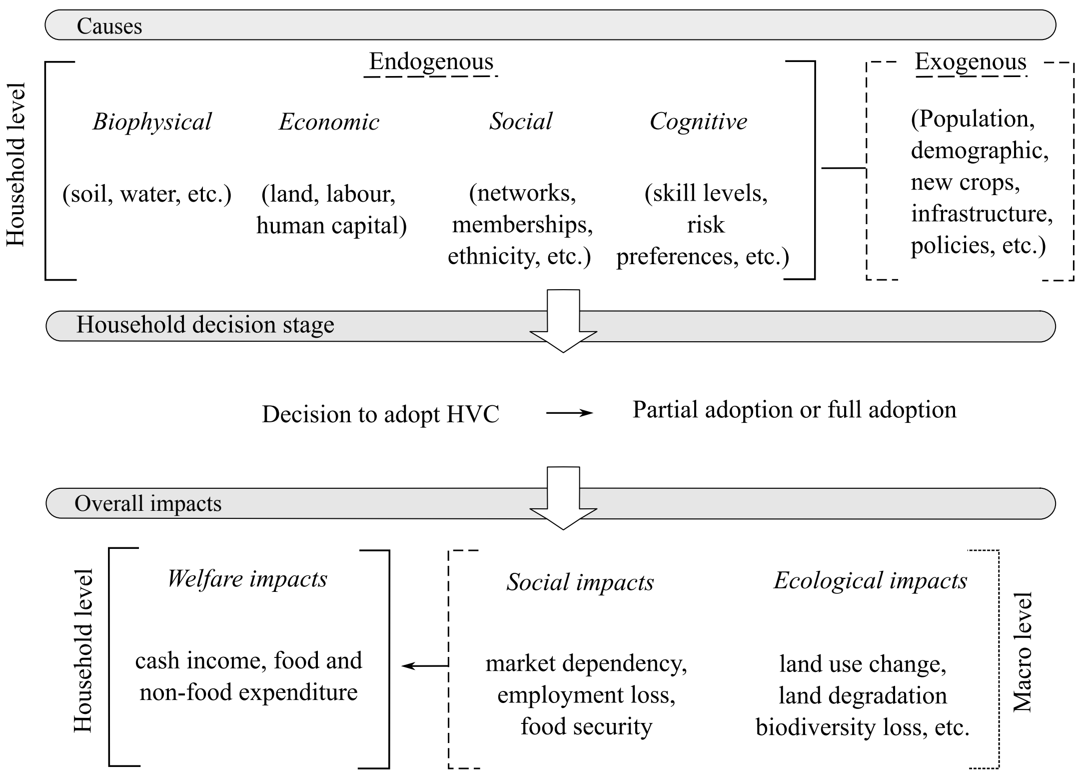

Figure 4.1 Conceptual framework of HVC adoption: determinants and impacts on household welfare and environment; adapted from von Braun and Kennedy (1994) and Jain et al. (2015).

According to the framework, a farmer's decision to adopt or not to adopt is voluntary and based on the expected benefits. His or her utility maximization depends on the

[2] http://eands.dacnet.nic.in/Cost_of_Cultivation.htm

heterogeneous individual household and farm characteristics and on macro level constraints or opportunities such as profitability of the new crop, government incentives, labour market imperfections, etc. After the farmer has decided to adopt an HVC, he or she has to make a decision on the area allocated to the different crops. Based on the observed and unobserved characteristics the farmer is expected to select one of the three strategies: 1) no adoption, 2) partial adoption and 3) full adoption. The choice of individual adoption strategy directly affects the household income and expenditure, and thus directly influences the overall household welfare. Furthermore, an individual adoption strategy when aggregated at a macro level, also has an indirect impact on the overall ecosystem and food security. For instance, the adoption of HVC over food crops, in our case wetland paddy, can result in the unintended consequence of change in land use from a diversity rich wetland system to a homogeneous system. The subsequent environmental consequences, such as, loss in biodiversity, water scarcity and change in rainfall pattern can indirectly reduce the household welfare.

4.3 Data and methdology

4.3.1 Study area

The study was undertaken in Wayanad district of Kerala in south India that is characterized by a heterogeneous agricultural system, a complex social and a sensitive ecological setting. Thus, the study area is suitable for analysing the relationship between HVC adoption and household welfare. Demographically, Wayanad is one of the least urbanized and most remote districts in Kerala, having the highest share of indigenous tribal population (31%), which depend on agriculture for their livelihoods. The indigenous inhabitants of Wayanad are mainly the Jain, Kuruma and Kurichya communities that own land, and the Paniya communities that are landless depending exclusively on agricultural labour for livelihood. Located on the margin of the Western Ghats at an altitude of 700 to 2100m, the region is one of the UNESCO world heritage sites and global biodiversity hot spots (Figure 4.2). It has the highest forest cover (83%) in Kerala measured in relation to its total geographical area.

The agricultural landscape of Wayanad traditionally consisted of high value plantations (coffee, pepper, cardamom and tea) in the highland and paddy cultivation in the valley. The average size of a land holding is 0.44 ha and 89% of these holdings are marginal farms with less than one hectare. Wayanad harbours rich agro-biodiversity especially associated with the wetland paddy fields (Parameswaran, Narayanan, & Kumar, 2014) and is home to more than 75 local rice cultivars, including two rice cultivars with geographical indicator status.

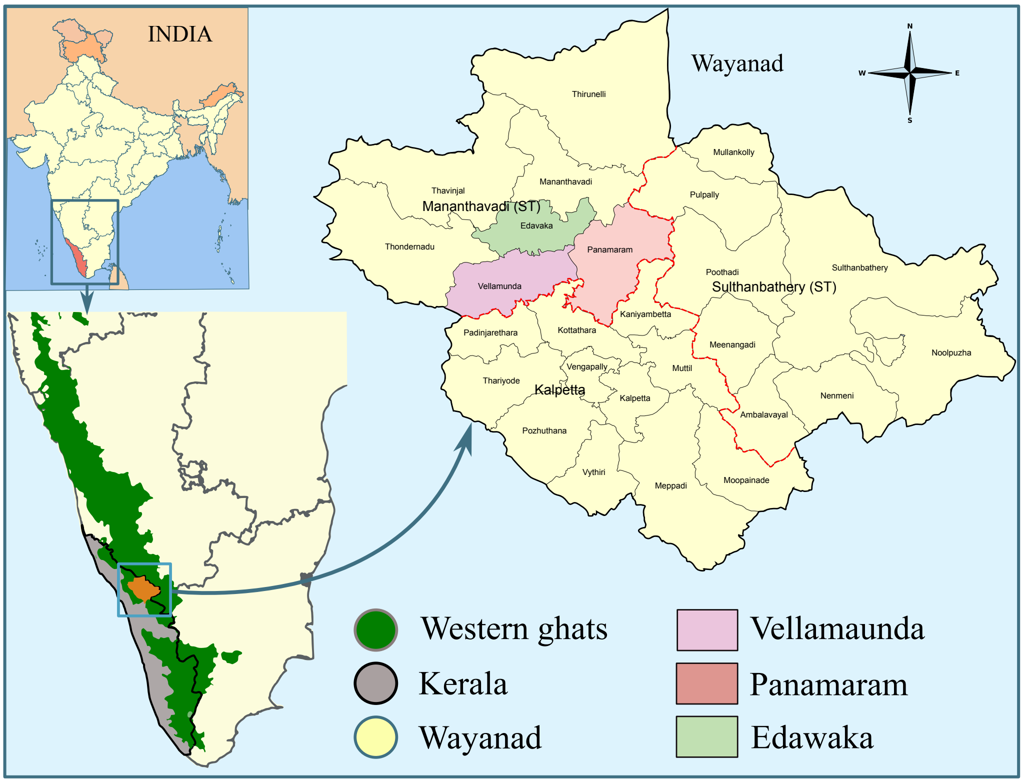

Figure 4.2 Map showing the sampling locations of Wayanad district, Kerala in south India

Paddy cultivation has a strong cultural meaning, particularly among the indigenous communities, as, rice being their staple food is essential to maintain food security (Kunze & Momsen, 2015). Wayanad is classified as highly vulnerable to climate change due to climate sensitive agriculture and forestry, and high dependence of marginalized tribal communities on these sectors (Nanadakumar, 2014). The economic value of functions and services lost in the region due to paddy-land adoption was estimated to be between ₹ 78,020 and ₹ 97,646 per hectare in the year 2000 (Gopikuttan & Kurup, 2004). The importance of paddy farming in the region, its richness in biodiversity and local rice cultivars, heterogeneous farming and socio-cultural system makes it an appropriate survey area.

4.3.2 Survey data and questionnaire

The study was conducted as part of the larger project "BioDIVA[3]" aimed at and sustainable land use and biodiversity conservation in Wayanad. The district is administratively divided into 27 *panchayats*, which are further divided into wards[4].

In the year 2010, a pilot survey was conducted in all the 27 *panchayats* (smallest unit of administrative governance) of Wayanad to rank the regions according to the adoption rate and land use change intensity. During the exploratory phase, focus group discussions and workshops took place with the stakeholders (farmers, landless labourers, policy-makers and elected officials) to refine the study objectives and the questionnaire. Based on the exploratory phase, the sampling frame was chosen from Manathavadi region covering three *panchayats*; Panamaram, Vellamunda and Edavaka (Figure 4.2). From each *panchayat*, a list of farming households was collected from the respective government agricultural office. Wards that were not suitable for HVC cultivation due to agro-ecological constraints were purposively excluded from the sample frame. The final sampling frame consisted of 16 wards in Panamaram, 13 wards in Edavaka and 19 wards in Vellamunda, from which a random sample of 304 farming households was drawn. In 2011, a pre-tested structured questionnaire was used to collect relevant information from the households through personal interviews by trained enumerators.

The questionnaire included sections related to the socio-economic status of household members such as age, gender and their employment status. Separate sections on land ownership, agricultural production, household income and expenditure were included in the questionnaire. The survey was addressed to the head of the household if he/she was available, else the spouse of the household head was surveyed. Few indigenous farm households, especially the Kurichya tribe have joint family system. Their land ownership is collective, but decision on what to plant is individual. In such cases, the details were collected on the land managed by the households.

[3] http://www.uni-passau.de/en/biodiva/home/

[4] A politically elected ward member at the *panchayat* represents each ward.

4.3.3 Estimation strategy

The decision to adopt or not is not random but voluntary. The household self-selects into one of the groups based on systematic differences in their characteristics or due to the information access and expected benefits of adoption (Amare et al., 2012; Di Falco, Veronesi, & Yesuf, 2011). Since the treatments are not randomly assigned as in a controlled experiment, the unobserved household characteristics, such as, skills, managerial ability and risk attitude may affect both the adoption decision and the outcome (Rao & Qaim, 2011). In this paper, we model farmers' adoption behaviours using the multinomial endogenous switching regression approach (ESR). The ESR approach controls for the bias from self-selection and estimates separate welfare equations for different adoption strategies (Teklewold, Kassie, Shiferaw, & Köhlin, 2013). The ESR approach involves two stages; in the first stage, selection equations on the farmers' choice of an adoption strategy from the available options are estimated using a multinomial logit selection model. In the second stage, the welfare outcomes are estimated using an ordinary least square regression by incorporating the selection correction terms from the first stage (Teklewold et al., 2013). Expectations from these welfare outcome equations are used to derive the actual and counterfactual scenarios and the treatment effects.

(a) Multinomial logit selection model

The household aims to maximize its welfare by choosing an adoption strategy j, from m available strategies (Khonje et al., 2015; Parvathi & Waibel, 2016). The three available adoption strategies in this study are; (1) non-adoption $m = 1$ as the base category denoted by subscript *'na'*, (2) partial adoption, cultivating HVCs along with paddy ($m = 2$) denoted by subscript *'pa'*, and (3) full adoption, cultivating only HVCs ($m = 3$) denoted by subscript *'fa'*.

The choice of an adoption strategy depends on the difference between expected welfare from the chosen adoption strategy and the welfare from the available alternative strategies. The household i chooses the adoption strategy j, if the expected welfare (G_{ij}) earned from the adoption strategy j is higher than the expected welfare (G_{im}) from choosing any other strategy m given as, $G_{ij} > G_{im} \quad \forall m \neq j$ (Teklewold et al., 2013). The expected welfare the household derives from their choice is given by the latent variable, G_{ij}^{*}, expressed as,

$$G_{ij}{}^{*} \;=\; Z_i\beta_j + \varepsilon_{ij} \tag{4.1}$$

where Z_i is the vector of exogenous variables in the model and ε_{ij} is the error term capturing the unobserved characteristics. The vector of explanatory variables, (Z_i), determines the observed adoption decision and thus affects the expected welfare differences from adoption. Z_i includes the socio-economic characteristics of the households (H_{ij}), farm characteristics (F_{ij}), and resource constraints (R_{ij}) faced by the household. Since G_{ij}^{*} is a latent variable, we only observe the actual decision made by the farmer. The following multinomial logit model, estimated by the maximum likelihood (ML) method, is used to determine probabilities of the household choosing an adoption strategy,

$$Y_{ij} = \beta_0 + \beta_1 F_{ij} + \beta_2 H_{ij} + \beta_3 R_{ij} + \varepsilon_{ij} \tag{4.2}$$

where Y_{ij} denotes the odds of household i adopting strategy j, instead of strategy $m, \forall m \neq j$. The vectors, F_{ij}, H_{ij} and R_{ij} represents farm characteristics, household characteristics and resource endowments of the household respectively and are the error terms. The detailed description of these independent variables and their references are given in Table 4.1.

Assuming the errors ε_{ij} are independent and identically Gumbel distributed, following Teklewold et al. (2013), the probability that the i th household chooses adoption strategy j can be estimated from the multinomial logit model as,

Probability (P_{ij}), that household i chooses adoption strategy, j=

$$P_{ij} = \frac{\exp(Z_i\beta_j)}{\sum\limits_{m=1}^{j} \exp(Z_i\beta_m)} \tag{4.3}$$

Table 4.1 Description of the variables

Variables	Description (unit of measurements)	Sources
(a) Dependent variables		
Per capita income	Per capita annual income of the household in Indian Rupees (INR)	(Parvathi & Waibel, 2016)
Per capita expenditure	Per capita annual consumption expenditure of household in INR	(Krishna, Euler, Siregar, Fathoni, & Qaim, 2015; Parvathi & Waibel, 2016)
(b) Independent variables		
Farm characteristics		
Number of plots	Total number of plots under cultivation by the household	(Becerril & Abdulai, 2010)
Land leasing	If the household is involved in land leasing (1=yes)	(Feder et al., 1985; Nair & Menon, 2006)
Distance to farm from dwelling	Distance from farm to dwelling in kilometres	(Teklewold et al., 2013)
Transport access	If the farm has access to transportation (1=yes)	
Household characteristics		
Off-farm income sources	Total number of off-farm income sources in the household	(Parvathi & Waibel, 2016)
Number of adults	Total number of adult residing in the household	(Muriithi & Matz, 2014)
Ethnicity	0=indigenous tribal household, 1=Non-indigenous household	(Curry et al., 2015; Krishna et al., 2015)
Resource constraints		
Farm size	Total paddy land cultivated by the household in acre	(Birthal et al., 2015)
MGNREGA participation	Total number of households members participating in MGNREGA	
Credit access	If the household has access to credit facilities (1=yes)	(Parvathi & Waibel, 2016)
Poverty status	0= Below poverty line (BPL); 1=Above poverty line (APL)	(Sharma & Singh, 2015)

Note: APL and BPL cut offs are taken from the Indian Planning Commission. Details of the parameters considered for identifying the cut off can be viewed in http://www.pbplanning.gov.in/pdf/BPL16-3-07.pdf (accessed on 10-05-16)
MGNREGA: Stands for Mahatma Gandhi National Rural Employment Guarantee Act, 2005, which guarantees the right to work in rural areas by providing 100 days of volunteer wage employment in every financial year to all adult citizens.
Source: Own compilation

In the second stage, welfare outcomes for each possible adoption strategy j of the i th household, given the set of explanatory variables X, can be constructed as,

$$G_{ij} = X_i\alpha_j + \mu_{ij} \qquad if\ G^*_{ij} > \max_{j \neq m}(G^*_{im}) \tag{4.4}$$

where, $j,m \in \{1,2,3\} \forall j \neq m$, μ's are the error terms distributed with mean zero and variance σ_j^2. For each household only one G_{ji} outcome is observed which occurs when $G^*_{ji} > \max_{j \neq m}(G^*_{im})$. If the error terms ε_{ij} in the selection equation Eq.(4.1) and the error terms μ_{ij} in the outcome Eq.(4.4) are not independent but correlated, then the OLS estimates of Eq.(4.4) will be inconsistent. In order to correct for inconsistency in the estimated parameters of Eq.(4.4), the selection correction terms generated from the probability estimates in Eq.(4.3) must be included in Eq.(4.4). By specifying a Normalized Dubin McFadden (DMF2) model, the correlation between the error terms in the multinomial logit selection equation and the welfare outcome equations can be accounted so that consistent estimates of outcome equations can be obtained (Bourguignon, Fournier, & Gurgand, 2007; Di Falco & Veronesi, 2013). From the assumptions of the DMF2 model, the errors, ε_{ij}'s and μ's are independent and the correlation between the errors sums to zero (Teklewold et al., 2013). Therefore, the following selection bias corrected welfare outcome equation based on a DMF2 model is specified by incorporating the inverse mills ratio (λ_j) computed from the probability estimates in Eq.(4.3) as,

$$G_{ij} = X_i\alpha_j + \delta_j\lambda_j + \omega_{ij} \qquad if\ G^*_{ij} > \max_{j \neq m}(G^*_{im}) \tag{4.5}$$

where δ_j is the covariance between the errors ε_{ij} and μ in Eq.(4.1) and Eq.(4.4) respectively. γ_j is the inverse mills ratio, and ω_{ji} is the error with mean zero. Since γ_j is an estimated parameter, in order to account for the heteroskedasticity generated from γ_j, the standard error in Eq.(4.5) is bootstrapped.

Instrument variables that influence the selection equation without affecting welfare must be included for proper identification of the model. These are access to transport, distance to farm from household, and number of plots in our study. The validity of these instruments has been tested using the falsification test (Di Falco & Veronesi, 2013). The results (Appendix A.1) reveal that they are jointly significant in explaining the selection of adoption strategy but not the welfare outcome, thus making the model robust.

HVCs improve household welfare by directly increasing the income earning potential that, in turn, increases the household's spending (Babu et al., 2014). Hence, expenditure per capita and income per capita were used as welfare indicators, similar to other adoption studies (Birthal et al., 2015; Jena & Grote, 2012; Parvathi & Waibel, 2016)

(b) Estimating Average Treatment Effects

Following Di Falco and Veronesi (2013); Teklewold et al. (2013) and Parvathi and Waibel (2016), the conditional expectations from Eq.(4.5) can be used to compute the average treatment effect on the treated (ATT) and average treatment effect on the untreated (ATU) for the actual and the counterfactual scenarios for different adoption strategies. For example, in the full-adoption case, Actual:

$$E(G_{fa_i}|j=3) = X_i\alpha_{fa} + \delta_{fa}\lambda_{fa} \quad \text{(full adopter remains full adopter)} \tag{4.6}$$

Adopters if decided to change regime (counterfactual):

$$E(G_{na_i}|j=3) = X_i\alpha_{na} + \delta_{na}\lambda_{fa} \quad \text{(full adopter becomes non-adopter)} \tag{4.7}$$

$$E(G_{pa_i}|j=3) = X_i\alpha_{pa} + \delta_{pa}\lambda_{fa} \quad \text{(full adopter becomes partial adopter)} \tag{4.8}$$

ATTs are derived as the difference in expectations between (ii) Eq.(4.6) and Eq.(4.7); and (iii) Eq.(4.6) and Eq.(4.8). Similarly, ATU's are calculated based on the conditional expectations as the difference between Eq.(4.10) and Eq.(4.9) as, Actual:

$$E(G_{na_i}|j=1) = X_i\alpha_{na} + \delta_{na}\lambda_{na} \quad \text{(non-adopter remains non-adopter)} \tag{4.9}$$

Counterfactual:

$$E(G_{fa_i}|j=1) = X_i\alpha_{fa} + \delta_{fa}\lambda_{na} \quad \text{(non-adopter becomes full adopter)} \tag{4.10}$$

The same concept is extended to other adoption strategies.

4.4 Results and discussion

In this section, we present the descriptive statistics of the variables followed by the results on the determinants of the adoption decision and its welfare impacts from the multinomial ESR model.

4.4.1 Descriptive statistics

The farmers were grouped based on the chosen adoption strategy as (i) non- adopters, (ii) partial adopters and (iii) full adopters. Table 4.2 shows that the per capita expenditure and income of the non-adopters were significantly lower in comparison to the partial as well as full adopters. However, there was no significant difference in the expenditure and income between partial and full adopters. Farm size was highest among the partial adopters. Households can only allocate land to different crops if land is not a constraint, and therefore farmers with more land have comparative advantage in partial adoption (Khonje et al., 2015). Transport access to farm was higher among adopters, indicating that these farms may be situated near to settlements towards the fringes of the valley. This argument is supported by descriptive statistics on the distance to farm from dwelling; farms of the households who adopted were found to be situated closer to their dwellings than the farms of the non-adopters. Number of plots was significantly different between adopters and non-adopters. Partial adopters were better-off than the other groups indicated by a significant difference in the poverty status of partial adopters and the other groups. We expected the indigenous tribal households to be more engaged in rice farming as they are traditionally attached to rice farming. However, we found no difference between the ethnicity of the households and their adoption status. This is concordant with the finding of Betz, Parameswaran, Suma, and Padmanabhan (2014) who reported that the traditional agrarian system of Kurichya and Kurma tribal communities is under transition to a mainstream market oriented system due to economic rationale and social re-organization in these communities.

Table 4.2 Descriptive statistics of the variables used

Variables	(1) Non-adopters		(2) Partial adopters		(3) Full adopters		(4) Full sample	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Income per capita ('000 Rs./year)	13.68	11.90	28.66***	36.60	29.88***	35.12	25.45	32.74
Expenditure per capita ('000 Rs./year)	22.61	18.00	28.28**	18.43	24.41*	14.77	26.05	17.66
Farm size (acre)	0.88	0.61	1.59***	1.11	1.11c	1.05	1.31	1.05
Credit access (1=Yes)	0.83	0.38	0.80	0.40	0.73	0.45	0.79	0.41
Distance to farm from dwelling (log) km	-1.69	1.49	-2.20**	1.41	-2.22**	1.55	-2.09	1.47
Ethnicity (1=Non-indigenous)	0.68	0.47	0.75	0.44	0.75	0.44	0.73	0.44
Land leasing (1=yes)	0.18	0.39	0.22	0.42	0.28	0.45	0.23	0.42
Number of adults	3.80	1.37	3.91	1.49	3.65	1.20	3.82	1.40
Number of plots	1.07	0.31	1.67***	0.80	1.17*c	0.48	1.41	0.70
Off-farm income sources	0.63	0.85	0.44**	0.79	0.42	0.71	0.48	0.79
Poverty status (1=APL)	0.63	0.49	0.78**	0.42	0.65b	0.48	0.71	0.45
MGNREGA participation	1.52	1.03	1.49	1.10	1.49	1.16	1.50	1.09
Transport access (1=Yes)	0.72	0.45	0.87**	0.34	0.94***a	0.23	0.85	0.36
Number of observation	71		160		72		303	

Note: ***, ** and * denote significant difference at 1%, 5% and 10% respectively from the base group (Non-adopters).

t-test for continuous normal variables; Wilcoxson rank-sum (Mann-Whitney) test for continuous but non-normal and χ^2- test for categorical variables are used.

MGNREGA stands for Mahatma Gandhi National Rural Employment Guarantee Act.

In column(4) a, b and c denote significant difference between partial adopters and full adopters at 1% , 5% and 10%.

Exchange rate at the time of survey was about 1US$=Rs. 46.67.

Source: Own computation.

The distribution of expenditure and income per capita of the three adoption strategies are given in Figure 4.3. The simple mean distribution functions show that partial and full adopters are likely to be better off than non-adopters. However, the differences in welfare outcome cannot be solely attributed to the adoption status, as there could be many other confounding factors that might influence welfare.

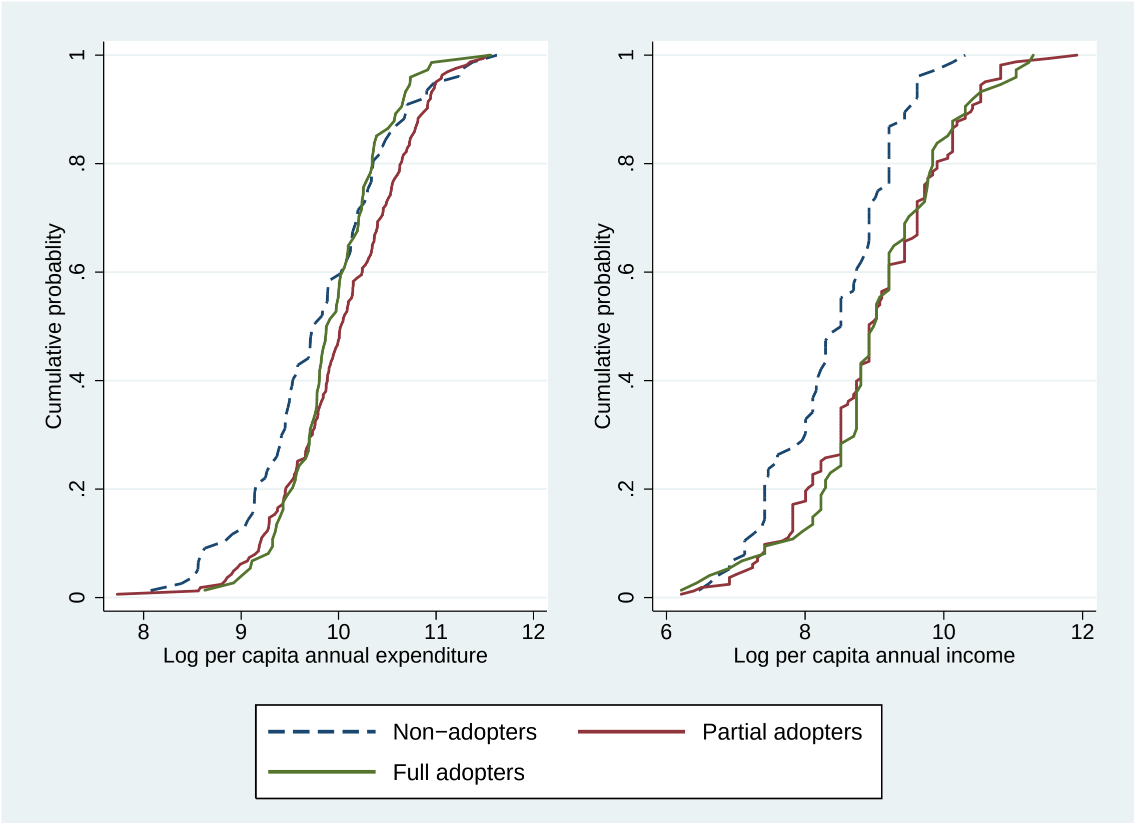

Figure 4.3 Distributions of income and expenditure (in log) of households according to the three different adoption strategies.
Source: Own computation

4.4.2 Determinants of HVC adoption

Table 4.3 presents the multinomial logit estimates of the selection Eq.(4.2). Farm size, transport access and distance to farm from dwelling are found to be statistically significant in explaining the HVC adoption decision. Farmers with more cultivated area are more likely to adopt HVC. They are able to allocate more area to different crops and hence can realize higher returns. Similar results were found by Sharma and Singh (2015) in India. The land preparation phase of transition from paddy to HVC is capital and labour intensive (Jose & Padmanabhan, 2015). Farmers can use their land as an asset collateral to avail agricultural loans, which can be utilized for land preparation and procurement of inputs, such as, improved planting material, fertilizers and pesticides in cash crop farming (Khonje et al., 2015).

Households with farms having access to transport are more likely to adopt HVC. As the average distance to the farm from the household increases, the odds for adoption decreases in partial as well as in full adopter groups. There could be two possible explanations to this result. First, it could be due to the convenience to transport bulky seed-materials and produce in case of HVC, such as, ginger and banana as compared to rice. Additionally, easy storage and transportation of the inputs, such as, fertilizers, seed materials and propping poles against wind protection, and better watch and ward of these HVCs favour the adoption on plots situated closer to the dwellings.

Second, farmlands with HVCs close to settlements and with transport access have high demand in the real estate market (Gopikuttan & Kurup, 2004). These plots are also preferred over the plots that cultivate paddy (Jose & Padmanabhan, 2015). Recent studies suggest that the rapid agricultural diversification (HVC adoption followed by shift from agricultural to non-agricultural economic activity) in Wayanad is a response to the growth in the tourism industry, capital inflows and expansion of urban market centers (Nagabhatla et al., 2015). The rising real estate demand for land have encouraged the farm land owners to sell their agricultural land giving up cultivation to cater to the demand from non-agricultural activities (Gopikuttan & Kurup, 2004; Münster & Münster, 2012; Nagabhatla et al., 2015). The land prices for rice cultivating farms are lower compared to those with land cultivating perennial HVCs (Sajikumar & Remya, 2015). Hence, if the farmer is adopting HVCs with the intention to participate in the active non-agricultural land market, he or she is more likely to adopt HVCs on plots with close access to transport and proximity to settlements.

Ceteris paribus, households above the poverty line have higher odds of being partial adopters than non-adopters. The HVC cultivation in India is capital intensive (Birthal et al., 2015) and also involves greater degrees of production and marketing risks in comparison to food crops (Joshi et al., 2006). Thus, farmers above poverty threshold are more able to mobilize capital for HVC adoption; this is confirmed by own results (Table 4.3). An increase in the number of plots increases the likelihood of HVC adoption. This finding is

Table 4.3 Multinomial logit results (selection equation)

Variables	Partial adopters	SE	Full adopters	SE
Transport access(1=Yes)	1.002**	(0.426)	1.985***	(0.615)
Distance to farm from dwelling (log)	-0.264**	(0.116)	-0.321**	(0.130)
Number of plots	2.225***	(0.535)	0.525	(0.592)
Number of adults	0.087	(0.135)	-0.107	(0.150)
Credit access (1=Yes)	-0.543	(0.443)	-0.750	(0.473)
Poverty status (1=APL)	0.963*	(0.546)	-0.013	(0.537)
Farm size (acre)	0.790***	(0.245)	0.512**	(0.226)
Land leasing (1=yes)	-0.725	(0.483)	0.315	(0.483)
Ethnicity (1=Non-indigenous)	-0.185	(0.531)	0.735	(0.564)
Off-farm income sources	-0.327	(0.230)	-0.297	(0.256)
MGNREGA participation	-0.032	(0.172)	-0.002	(0.189)
Constant	-4.291***		-2.888**	
Chi-square	117.746***			
Pseudo R^2	0.191			
N	303			

Note: Robust standard errors in parentheses; ***, significant at 1%; **, significant at 5%; *, significant at 10%
Base category: Non-adopters.
Source: Own computation.

supported by Guillerme et al. (2011) where the authors argue land fragmentation, as the cause of land use intensification and monoculture of commercial crops in Kerala.

4.4.3 Welfare impacts of heterogeneous adoption

The welfare outcome variables, income per capita and expenditure per capita were right-skewed and hence were transformed into logarithms to obtain a more symmetric distribution. The second stage coefficient estimates of multinomial endogenous switching regression are given in Appendix A.2. These results are not discussed in detail, as in this section we focus on the impact of different levels of adoption on the welfare outcome.

However, most of the selection error correction terms excluding income per capita for partial adopters were not significant, implying, non-adopters will have the same welfare outcome effect as that of the adopters if they decide to adopt HVCs.

Table 4.4 presents the results of the actual and counterfactual analysis of the welfare impacts of different adoption strategies, allowing us to identify the strategy that brings a maximum welfare to the farmers from HVC adoption. Since the welfare outcome variables are log transformed, we discuss the results in terms of percentage changes[5].

The first two columns of the table show expected welfare outcome under actual and counterfactual conditions of varying adoption strategies. The last column presents the treatment effects on the treated (ATT) of each HVC adoption strategy on income per capita and consumption expenditure, calculated as the difference between actuals and counterfactuals. The treatment effect on the untreated (ATU) is calculated as the difference between counterfactuals and the actual; for example, we compare the income per capita of non-adopters if they decide to partially adopt, with the actual income per capita of the non-adopters.

The ATT results show that partial adopters, if they decide to become non-adopters, would notice a reduction in income per capita by 39%. Further, if households that have fully adopted HVCs decide to cultivate paddy, then they would experience a loss of 21% in their income. However, if the full adopter households become partial adopters, then they would have a gain of 20% in their income per capita. The results, hence, suggest that partial adoption is a better adoption strategy than full adoption and non-adoption strategies as it results in higher welfare.

ATU effects of per capita income also reveal that the partial adopters are better-off by a 33% gain in income than being non-adopters of HVCs. Similarly, a partial adopter will experience a 24% drop in income if he or she decides to become full adopter. The ATU results of consumption expenditure also imply that the non-adopters can increase their consumption expenditure by 49% if they choose to become partial adopters of HVCs. Even though the non-adopters can increase their spending by 18% by switching to the full HVC adoption strategy, the pay-off is relatively lower when compared to choosing a

[5]Multiplying ATT by 100 give a rough approximation of the percentage difference. The exact difference in percent is given by $100(e^{ATT} - 1)$.

Table 4.4 Treatment effects of HVC adoption on non-adopters (NA), partial adopters (PA) and full adopters (FA)

Welfare outcome	Actual		Counterfactual		ATT
Log income per capita					
	PA remains PA	9.726	PA becomes NA	9.331	0.395***
		(0.051)		(0.076)	(0.092)
	FA remains FA	9.774	FA become NA	9.561	0.213*
		(0.089)		(0.069)	(0.112)
	FA remains FA	9.774	FA become PA	9.978	-0.204**
		(0.089)		(0.054)	(0.100)
Log expenditure per capita					
	PA remains PA	10.049	PA becomes NA	10.055	-0.006
		(0.036)		(0.047)	(0.062)
	FA remains FA	9.965	FA become NA	9.947	0.018
		(0.031)		(0.038)	(0.049)
	FA remains FA	9.965	FA become PA	9.986	-0.021
		(0.031)		(0.027)	(0.046)
Welfare outcome	Counterfactual		Actual		ATU
Log income per capita					
	NA become PA	9.488	NA remain NA	9.156	0.332**
		(0.084)		(0.062)	(0.132)
	NA become FA	9.236	NA remain NA	9.156	0.080
		(0.088)		(0.062)	(0.107)
	PA become FA	9.486	PA remain PA	9.726	-0.240***
		(0.078)		(0.051)	(0.093)
Log expenditure per capita					
	NA become PA	10.268	NA remain NA	9.771	0.497**
		(0.109)		(0.046)	(0.165)
	NA become FA	9.954	NA remain NA	9.771	0.184*
		(0.103)		(0.046)	(0.112)
	PA become FA	10.109	PA remain PA	10.049	0.060
		(0.040)		(0.036)	(0.060)

Note: NA: non-adopters; PA: partial adopters; FA: full adopters;
Standard errors in parentheses.
***, significant at 1%; **, significant at 5%; *, significant at 10%.
Source: Own computation.

partial adoption strategy. This again reinforces our finding that partial adoption is a better adoption option in comparison to the other available strategies.

In other words, from the analysis of counterfactuals of income and expenditure, even though HVC adoption results in increased welfare outcome, we find statistical evidence to infer that the household welfare can be maximized by following the most effective strategy of growing HVC in combination with paddy. Our results are corroborated by Birthal et al. (2015), where the odds of reducing the poverty for smallholders in India remain unchanged when the intensity of HVC adoption was above 60% of the total cultivated area, suggesting that further expansion of area under HVCs beyond the threshold might not increase farmers' welfare.

4.5 Conclusion

The objectives of the paper were to analyse the determinants of HVC adoption and the impact of adoption on the household welfare, especially, of small and medium farmers in India. The study uses cross sectional household data from 303 farming households collected in 2011 from Wayanad district of Kerala, South India. This is a region, which is ecologically sensitive and rich in biodiversity, and where agriculture is in a transition stage from subsistence paddy farming to HVC, such as, banana and ginger. Annual per capita income and per capita consumption expenditure were used as proxies for measuring household welfare. Multinomial endogenous switching regression model with selection bias correction was applied to assess the impact of heterogeneous adoption decision on household welfare.

The analysis of the determinants of adoption showed that the adoption of HVC is significantly related to the landholding size, distance to farm from dwelling, transport access and number of cultivated plots. Overall, our findings support the hypothesis that the adoption of HVCs increases the welfare of farmers. The analysis of the counterfactual estimates indicates that the non-adopters can realize an increase in their income and spending if they adopt HVC. The estimates of heterogeneous impacts of levels of adoption reveal that the households which grow both HVC and paddy rice, meaning, that they have at least allocated a proportion of their cultivable area to food crops, are found to have higher income and consumption expenditure than the non-adopters and full adopters. Therefore, the question arises, as to what explains the positive impact on the household welfare of partial adopters. First, in case of full adopters due to the long growing duration of HVCs such as ginger, banana and areca nut, by allocating their entire land to HVCs the food supply and household income might be negatively affected, thus reducing their welfare in the short and medium term (Babu et al., 2014). Second, the agricultural intensification and incorrect cultivation practices associated with HVCs have resulted in negative ecological consequences leading to the degradation of land and reduction in productivity of HVCs (Nair & Menon, 2006). By allocating a certain proportion of their farm land to paddy, the partial adopters are able to reduce the intensity of land degradation thus restoring the ecological balance and minimize the risk arising from production. Our argument is also supported by Parameswaran et al. (2014) who noted that paddy fields and associated diversity play a significant role in controlling and restoring the agro-ecological balance of the wetland system.

Commercial crop adoption is seen as an irreversible phenomenon that is triggered by economic growth (Pingali, 2004) and is aimed at the improvement of the rural living conditions. At the same time, it is seen as a major threat to the environment and biodiversity (Nadesapanicker et al., 2011). In view of this, the government of Kerala has taken an initiative to preserve the wetland paddy in the state, the most important ones being the Kerala Conservation of Paddy Land and Wetland Act of 2008 and the scheme for comprehensive development of rice. Our findings will facilitate the policy-makers in developing more targeted policies and implementation plans for such initiatives, which would not only aim at improving the welfare of farmers but also maintain the ecological balance and overall sustainability of the system. The intrinsic differences among the groups of households and heterogeneity in the welfare impact suggest for policy measures and incentive programs addressing HVC adoption that are not generalized, but effectively targeted in consideration with the socioeconomic conditions and welfare differentials across the target groups.

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Chapter **5**

EMISSION TAXES AS A GHG MITIGATION MECHANISM IN AGRICULTURE: EFFECTS ON RICE PRODUCTION OF INDIA

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Appendix A

Table A.1 Results of the falsification test for instrument validity

Variables	Model 1: Multi logit		Model 2: OLS	
	Partial adopters	Full adopters	Expenditure per capita (log) of non-adopters	Income per capita (log) of non-adopters
Transport access	1.002**	1.985***	−0.092	0.110
	(0.426)	(0.615)	(0.207)	(0.210)
Distance to farm from dwelling (log) km	−0.264**	−0.321**	0.018	0.118*
	(0.116)	(0.130)	(0.055)	(0.065)
Number of plots	2.225***	0.525	0.090	0.139
	(0.535)	(0.592)	(0.277)	(0.194)
Number of adults in the household	0.087	−0.107	−0.077	−0.241***
	(0.135)	(0.150)	(0.059)	(0.072)
Credit access (1=Yes)	−0.543	−0.750	−0.100	0.233
	(0.443)	(0.473)	(0.188)	(0.279)
Poverty status (1=APL)	0.963*	−0.013	0.430**	0.260
	(0.546)	(0.537)	(0.185)	(0.243)
Farm size (acre)	0.790***	0.512*	0.084	0.330
	(0.245)	(0.266)	(0.122)	(0.201)
Land leasing (1=yes)	−0.725	0.315	0.272*	−0.260
	(0.483)	(0.483)	(0.138)	(0.274)
Ethnicity (1=Non-indigenous)	−0.185	0.735	0.132	−0.048
	(0.531)	(0.564)	(0.171)	(0.237)
Off-farm income sources	−0.327	−0.297	0.040	0.141
	(0.230)	(0.256)	(0.099)	(0.117)
MGNREGA participation	−0.032	−0.002	−0.113	−0.055
	(0.172)	(0.189)	(0.070)	(0.145)
Constant	−4.291***	−2.888**	9.814***	9.474***
	(1.039)	(1.171)	(0.512)	(0.701)
Sample size	303		72	71
Wald test on selection instruments	χ^2=28.07***	χ^2=16.021***	*F-stat*=0.116	*F-stat*=1.782
R-square /pseudo R	0.191		0.296	0.377

Note: ***, significant at 1%; **, significant at 5%; *, significant at 10%;
Robust standard errors in the parenthesis.
Multinomial logit base category: Non-adopters.
MGNREGA stands for Mahatma Gandhi National Rural Employment Guarantee Act.
APL stands for Above Poverty Line.
Source: Own computation

Table A.2 Multinomial endogenous switching regression results (outcome equations)

Variables	Income per-capita						Expenditure Per-capita					
	Non-Adopters	SE	Partial-Adopters	SE	Full-Adopters	SE	Non-Adopters	SE	Partial-Adopters	SE	Full-Adopters	SE
Number of adults in the HH	-0.248***	-0.095	-0.275***	-0.053	-0.081	-0.125	-0.072	-0.077	-0.194***	-0.038	-0.120	-0.080
Credit access	0.127	-0.399	0.028	-0.209	-0.052	-0.376	-0.164	-0.242	-0.292***	-0.099	-0.097	-0.167
Poverty status	0.358	-0.473	0.374	-0.339	0.953*	-0.523	0.571**	-0.302	0.020	-0.204	-0.005	-0.264
Farm size (acre)	0.282	-0.264	0.353***	-0.08	0.242	-0.214	0.127	-0.195	0.065	-0.055	0.026	-0.090
Land leasing	-0.188	-0.394	0.504***	-0.195	1.010**	-0.406	0.249	-0.247	-0.014	-0.091	0.163	-0.194
Ethnicity	-0.061	-0.444	0.154	-0.344	-0.102	-0.603	0.113	-0.266	0.490**	-0.196	0.535**	-0.271
Off-farm income sources	0.152	-0.150	0.104	-0.105	-0.233	-0.233	0.025	-0.114	0.126*	-0.073	-0.065	-0.127
MGNREGA participants	-0.046	-0.161	0.076	-0.074	-0.029	-0.126	-0.118	-0.088	-0.044	-0.045	-0.054	-0.094
_m0 (δ_{na})	0.168	-0.861	-1.880	-1.261	0.031	-1.849	0.344	-0.679	-0.072	-0.83	-0.334	-0.794
_m1 (δ_{pa})	0.822	-2.346	-1.431*	-0.86	0.139	-1.967	1.335	-1.987	0.104	-0.55	-0.035	-0.932
_m2 (δ_{fa})	0.467	-1.605	-1.071	-0.924	0.141	-0.733	0.759	-1.365	0.140	-0.637	0.230	-0.293
Constant	9.935***	-1.050	9.439***	-0.471	9.090***	-1.388	10.293***	-0.743	10.550***	-0.276	9.776***	-0.609

Note: Number observation is 303; δ_{na}, δ_{pa} and δ_{fa} are the selection error correction terms from Eq. (4.5).
Bootstrapped standard errors at 200 replications in parentheses.
***, significant at 1%; **, significant at 5%; *, significant at 10%.