Doctoral Dissertation

Sustainability of Organic Farming Compared to Conventional Farming in Chitwan District of Nepal

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Sustainability of Organic Farming Compared to Conventional Farming in Chitwan District of Nepal

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Dedication

I dedicate this dissertation to my late grandfather Mr. Man Mohan Lal Singh (1933-2012) and my beloved parents Mr. Madan Mohan Lal Singh and Mrs. Andira Singh for their constant support and unconditional love.

Summary of the Dissertation

Agriculture is the source of food, income and employment for majority of the population in Nepal. The government prioritizes on commercialization of agriculture through conventional means for the overall economic development. But declining soil fertility, negative repercussions on environment and health of farmers due to use of agro-chemicals and market demand reinforced the organic movement in Nepal. Climate change and food insecurity are other important issues Nepalese agriculture sector should deal with. Organic farming is known to be the most sustainable method that claims to tackle these issues. However, sustainability needs to be assessed from three aspects (social, economic and environmental) and is very context-specific. This study compares the sustainability of organic and conventional farming method from two aspects; economic and environmental in Chitwan district of Nepal where group conversion to organic farming exists in three adjoining village development committees, the lowest administrative unit, namely, Phoolbari, Shivanagar and Mangalpur. The respondents were selected by stratifying individual households based on their membership in a group formed for the purpose of organic farming. From the field survey, it was realized that not all farmers belonging to such group are practicing organic farming. Likewise, not all farmers not belonging to such group are practicing conventional farming. Therefore, there are both kinds of respondents within and outside such group, although most of the organic farmers are group members. The final data of 285 households is used for the analysis.

First, the study analyzes impact of livelihood assets of a household on adoption of a farming method. In any adoption studies of agricultural innovation, livelihood assets are as important as

agro-ecological variables and farmers' perception. For this purpose, this study uses bivariate probit model. The result shows that households having higher livestock holding and receiving higher number of organic farming related training are more likely to practice organic farming. Livestock holding still plays an important role because livestock manure is the main source of organic fertilizer. Training complements the technical knowledge required to practice organic farming, which is not just following the traditional way of farming but assimilating them with modern scientific knowledge as well. Thus, these two household characteristics should be emphasized for increasing the adoption rate of organic farming.

In order to evaluate environmental implication of these farming methods, adoption of organic means of crop management practices has been analyzed. It has been divided into two categories: soil fertility management (mulching, compost-shed, bio-slurry, plastic cover and vermicompost) and pest management (bio-pesticide) practices. The study uses multivariate probit model to analyze impact of livelihood assets on the aforementioned practices. The study shows that even though there is an influx of modern inputs like chemical fertilizers, pesticides and micronutrients; conventional farmers also incorporate all organic means of soil fertility and pest management practices analyzed in this study. Although adoption rate is higher among organic farmers, indicating that organic farmers are keener on adopting such practices. However in some instances the adoption of these sustainable but high investment requiring practices can be hindered by lack of fund in which case fund assistance should be provided. Training also complements technical knowledge required to implement these practices. Farmers also tend to complement most of such practices, indicating that any additional organic means of soil fertility or pest management practices can be introduced to those households who are already adopting one of such practices.

But sometimes these practices become substitutes because of their nature of relying on the same input, such as mulching and biogas that directly or indirectly relies on crop residue. Thus, any effort to enhance such adoption rate can consider these characteristics of various practices.

Economic benefit is probability the most important reason for smallholder farmers to undertake any practice. This study analyzes crop diversification, farm income, gross farm cash income, production and net return for this matter. For assessing crop diversification, this study uses Shannon Diversity Index that captures both richness (number) and evenness (abundance) of crops, and analyzes impact of livelihood assets on it using ordinary least square model. Organic farm in the study areas is richer in integrating more number of crop types (richness) but is poor in evenness, which resulted in having lower Shannon Diversity Index than conventional farm. Since crop evenness is better indicator of improved productivity than crop richness, it can be implied that farmers, especially organic farmers, should be made aware of this fact in order to improve their overall productivity. The socioeconomic variables that have significant positive impact on Shannon Diversity Index are education attainment, livestock holding, non-farm income, group membership and training. Clearly, educated farmers have more knowledge on the benefits of having various crops and its advantage to one's health. Non-farm income allows farmers to intensify diversification for own household consumption rather than having to specialize for increasing income. Membership in a group formed for the purpose of organic farming and training related to organic farming can improve Shannon Diversity Index because the purpose of such group formation and training is to make farmers aware of benefits of agro-ecological principles, resulting in improvement of soil fertility and the production. Finally farther the distance to the market, it encourages farmers to have better Shannon Diversity Index because they will prioritize on being self-sufficient and avoid buying or selling in the market to save the transportation cost.

Differences in farm income between the two farming methods is evaluated using ordinary least square model. For the farm income, which is the monetary valuation of overall farm output whether self-consumed or sold in the market; education of household head, farming as primary occupation of household head, livestock holding, farm size, farther distance to market and Shannon Diversity Index have a positive contribution. The second step involves assessing the livelihood assets' impact on household's decision to market the crops and to analyze only those households who have actually sold crop/s in the market to see the extent of gross farm cash income farmers belonging to two different farming methods are able to earn. For the former analysis, bivariate probit model is used while ordinary least square model is used to assess the intensity of gross farm cash income earned. Household's decision to sell crops in the market is influenced positively by farm size, farm income, credit and knowing final price at which the consumer buys; while tenant farmers, labor availability, livestock holding and group membership decreases its probability. Conventional farmers earn higher gross farm cash income than organic farmers because at present, the production per hectare, commercialization rate and price per unit for almost all the crops is higher for conventional crops. In addition to that, access to the premium market is very limited and has not been able to make any significant contribution to farmers' income. Since monetary benefit can attract farmers to divert their labor force in farming activities and specifically making monetary return from organic farming more competitive, making access to premium market should be very effective to boost the adoption rate of organic farming. For this, organic farmers should be linked with potential sellers not just in other cities but an effort should be made towards making

market linkage in strategic places of the local area. Doing so will give farmers more control over price and can quality check their products, which is one of the issues they are facing as a result of selling organic products through middlemen in the premium market existing in other cities.

This study compares production and net return from carrot cultivation, which according to key informant is the most commercial non-staple crop in the study areas. To analyze the differences in the cost of production and the net return under two farming methods, t-test is utilized while to evaluate impact of livelihood assets' on the carrot production, again ordinary least square model is applied. The result finds that conventional carrot production is a high cost investment method while organic carrot production is characterized by requiring higher labor, providing lower production but needing lower investment as well. The net return is also higher in conventional carrot production though not significantly different than organic carrot production. Currently, only 6% of total organic carrots produced by the organic farmers could be sold through a cooperative in the cities at 9% premium. Thus, if access to premium market can be improved, it would also significantly improve the net return from organic carrot production. This study also uncovers that among Phoolbari, Shivanagar and Mangalpur village development committees, the latter two should be prioritized more for increasing the adoption rate of organic farming or improving farming performance in general because farmers in these two areas have lower organic farming adoption rate, Shannon Diversity Index and gross farm cash income. Overall, by assisting to strengthen the economic and environmental sustainability of a farming method will in turn support the livelihood assets of the households.

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Acronyms and Abbreviations

AICC	Agriculture Information and Communication Center
APEDA	Agricultural and Processed Food Products Export Development Authority
APP	Agriculture Perspective Plan
BADC	Bangladesh Agricultural Development Cooperation
BNOP	Bhutan National Organic Program
BOPMA	Bangladesh Organic Products Manufacturers Association
BPM	Bivariate Probit Model
BT	Bacillus Thuringiensis
CBS	Central Bureau of Statistics
CertAll	Certification Alliance
CH_4	Methane
CO_2	Carbon Dioxide
DADO	District Agriculture Development Office
DAP	Diamonium Phosphate
DFID	Department for International Development
DoAE	Directorate of Agriculture Extension
eg.	Example
EM	Effective Microorganisms
EPA	Environmental Protection Agency
ESCAP	Economic and Social Commission for Asia and the Pacific
et al.	And others
Euro GAP	Euro Good Agricultural Practice
FAO	Food and Agriculture Organization
FFS	Farmer’s Field School
FiBL	Research Institute of Organic Agriculture
FORWARD	Forum for Rural Welfare and Agricultural Reform for Development

FYM	Farm Yard Manure
G.ecbo	Global Explorers to Cross Borders
GDP	Gross Domestic Product
GELs	Global Environmental Leaders Education (GELs) Program
GHG	Greenhouse gas
GHK	Geweke-Hajivassiliou-Keane
ha	Hectare
HDRA	Henry Doubleday Research Association
HH	Household
HHH	Head of Household
HICEC	Hiroshima International Center for Environmental Cooperation
HORTEX	Horticulture Export Development
i.e.	That is
IAAS	Institute of Agriculture and Animal Science
ICCOA	International Competence Centre for Organic Farming
ICS	Internal Control System
IFDC	International Fertilizer Development Center
IFOAM	International Federation of Organic Agriculture Movements
IFPRI	International Food Policy Research Institute
IIA	Independence of Irrelevant Alternative
ILO	International Labour Organization
INSAN	Institute for Sustainable Agriculture Nepal
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
ISFM	Integrated Soil Fertility Management
IUCN	International Union for Conservation of Nature
K	Potassium
Kg	Kilogram

Km	Kilometer
LFU	Labor Force Unit
Ln	Natural log
LSU	Livestock Unit
masl	Meters Above Sea Level
mm	Millimeter
MNL	Multinomial Logit
MoAD	Ministry of Agriculture Development
MoE	Ministry of Environment
MoHP	Minstry of Health and Population
MOP	Muriate of Potash
MVP	Multivariate Probit
n	Number of households
N	Nitrogen
N_2O	Nitrous Oxide
NGO	Non-Governmental Organization
NOAAB	National Organic Agriculture Accreditation Body
NPC	National Planning Commission
NPOP	National Programme for Organic Production
NRs.	Nepalese Rupees
OCMPs	Organic means of Crop Management Practices
OCN	Organic Certification Nepal
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Square
P	Phosphorous
PGS	Participatory Guarantee System
SD	Standard Deviation
SHDI	Shannon Diversity Index

SML	Simulated Maximum Likelihood
STATA	Data Analysis and Statistical Software
UN	United Nations
UNCTAD	United National Conference on Trade and Development
UNEP	United Nations Environment Programme
US$	United States Dollar
VDC	Village Development Committee
VIF	Variation Inflation Factor
WFP	World Food Programme
WTO	World Trade Organization

Chapter 1. Background of the study

1.1 Introduction

The method of how agriculture is being practiced has changed significantly since the 20th century, at least in the industrialized countries. A massive breakthrough in agricultural technologies backed by modern plant breeding, improved agronomy, and the growth of conventional fertilizers and modern pesticides brought remarkable changes in food productivity (IFPRI, 2002). This change of agricultural method is called 'Green Revolution' and is also synonymous with conventional farming. It is a farming method that involves monocropping, which basically means eradicating biodiversity to maintain uniformity. In other words, such kind of commercial farming boasts economies of scale through maximum production and at the same time decreasing cost to the lowest possible. In addition to irrigation, it adopts various technologies for this matter, such as using pesticides to avoid destroying crops by insects and animals and to control weed; synthetic chemical fertilizers as a source of nutrient for plants; and using antibiotics and growth hormones to prevent diseases in the livestock and increase their growth and productivity. Later this method of farming was criticized for it brought environmental, economic and social concerns. Excessive and inappropriate use of chemical fertilizers and pesticides polluted ground water, streams, rivers and oceans; degraded land; caused professional hazard; killed beneficial insects and other wildlife; and affected those who consumed it through food residue (DFID, 2004; Kassie & Zikhali, 2009). Moreover there has been regional disparities in food productivity following this kind of farming method among wealthier and subsistence farmers due to geo-political factors. When the world per capita agricultural production increased by 25% compared to 1960 level, region wise it showed different figures. Asia and Latin America were able to increase per capita food production by 76% and 28%, respectively, while it was 10% less per person in case of Africa (DFID, 2004). A study in Sub-Saharan Africa identified lack of infrastructure, high transport cost, limited investment in irrigation, and unsuitable pricing and marketing policies to have hindered farmers to reap the benefits from green revolution (IFPRI, 2002). Therefore, increasing issues of food security and resource degradation has now raised the question of sustainability of such farming method (DFID, 2004).

Realizing the negative consequences, many alternatives to conventional farming has been initiated, one among which is organic farming. According to IFOAM (2008):

> Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved. (Definition of Organic Agriculture, para. 3)

From this definition it can be understood that organic farming excludes the use of chemical fertilizers and pesticides, genetically modified organisms, growth regulators, livestock feed additives or hormones. Instead it relies on natural processes such as crop rotation, animal manure, green manure, natural enemies, pest-free plant varieties, companion planting, integrated pest management, etc. to control pests, weeds and diseases, maintain health of soil and that of all the living organisms involved as well. It emphasizes on the use of locally available resources and optimum production under given environmental condition. Organic farming is known to be one of the most sustainable forms of production method. Many might perceive organic farming to be a traditional form of farming which used to be in practice before the introduction of green revolution. However others understand it as incorporating best of traditional farming practices and assimilating them with modern scientific knowledge (HDRA, 1998).

1.2 Problem statement

Nepal is a landlocked country in South Asia, bordered by China to the north and India to the south, east and west. With an area of 147,181 square kilometers, it is the 93rd largest country in the world. It extends from 80°4' E to 88°12' E longitude and 26°22' N to 30°27' N latitude. Ecologically, it is divided into three zones: mountain, hill and plain (Tarai) with an altitudinal variation ranging from 60 meters above sea level (masl) in the south to 8,848 masl in the north within a distance of only 160 kilometers (kms). Due to the vast variation in topography and altitude, its climate varies from sub-tropical to alpine (MoE, 2011; Bhattarai, 2006). Although only about 20% of the total area is cultivable (33% is forested and rest of the part is mostly mountainous), agriculture is the backbone of Nepalese economy contributing 36% to the Gross Domestic Product (GDP) and forming the source of income and employment for 66 percent of the population (SECARD, 2011; MoAD, 2015; MoE, 2011).

Agriculture being the source of food, income and employment for majority of the population, Nepal government has always emphasized this sector for dealing with key issues of poverty alleviation and economic development. Among others, commercialization of agriculture has been deemed necessary to bring much needed changes in the economic growth of Nepal (Samriddhi, 2011). Improving agriculture through increased use of chemical fertilizers and pesticides, and high yielding varieties are the main concern for the government, which has also been prioritized in 20-year Agriculture Perspective Plan (APP) (from 1995-2015). Besides that national education, research, extension and communication methods are mainly concentrated in high input agriculture method in Nepal (Tamang, Dhital, & Acharya, 2011). Despite efforts to uplift this sector, agricultural productivity growth rate remains lower compared to other countries (Samriddhi, 2011; Ghimire, Dhungana, Vijesh V. Krishna, & Sherchan, 2012). Moreover such input-intensive farming method is known to degrade environmental services and stagnate or decline production overtime due to intensive and monocropping pattern method (Samie, Abedullah, & Kouser, 2010). The problems related to this kind of farming method is now emerging through declining soil fertility and production in those areas of Nepal which have the history of long-term use of chemical fertilizers and pesticides (Bhatta & Doppler, 2010; Weiss, 2004; Shrestha & Neupane, 2002).

Declining soil fertility, negative repercussions on environment and health of farmers due to use of agro-chemicals and market demand reinforced the organic movement in Nepal (Bhatta & Doppler, 2010; Weiss, 2004) and it has been growing gradually (Adhikari R. K., 2011). Organic farming is conceived to be a sustainable approach to food production method, an alternative to ecologically unsound practices of conventional farming. Specifically in Nepalese context, it has potential due to exclusion of costly agro-chemicals, ecological diversities and higher labor availability in agriculture sector (Pokhrel & Pant, 2009), thus making it self-reliant. In addition to that, the already evident effect of climate change through declining food productivity (WFP, 2009) calls for a more resilient agricultural practice such as organic farming to withstand unpredictable climate and assure production sustainability which is likely to be economically and socially just as well.

Organic farming though known to be a sustainable approach to conventional farming, its share as of 2013 was only 0.2% (9,361 ha) of total agricultural land (which is lower than global share of 0.98%) (FiBL & IFOAM, 2015). There are various reasons to why coverage of organic farming is significantly lower than conventional farming method. Organic farming is most widely known for providing healthy lifestyle, either through residue free food consumption or offering a hazard-free farming environment. It is also known to adapt, mitigate and being resilient to changing climate, which is a burgeoning issue in present day scenario. It is known to improve soil fertility for sustaining the productivity overtime, be self-reliant by making use of locally available resources, to reduce external shocks (climate or market related) through crop diversification and to allow farmers to enjoy higher profit through accessing premium price (Scialabba, 2007). But on the contrary, it is also known to produce less compared to its conventional counterpart, is labor intensive and often times difficult to get hold of enough organically acceptable inputs as prescribed in the guidelines of the said country (Trewavas A. , 2002; Meisner, 2007). Another reason is organic food are generally more expensive and there could be a number of explanations for this. Firstly, organic food supply is less than demand. Higher labor cost per unit of output and lower efficiency in economies of scale due to diversity of enterprises also contributes to higher price. Finally, no matter how limited the quantity of production is, it still needs to follow the stricter regulation to maintain its integrity through the process of certification and other post-harvest requirements (processing, transportation and marketing). Moreover, conventional food does not reflect the actual environmental and health cost incurred during its production and consumption phase (Belicka, 2005; FAO, 2014). Conventional farming though is known to cause environmental (polluting water source, land degradation, biodiversity loss), economic (increasing input cost, decreasing trend of output) and social concerns (occupational risk, food residue, regional disparities) (DFID, 2004; Kassie & Zikhali, 2009; Scialabba, 2007); its ability to produce more (IFPRI, 2002)makes it more desirable as it meets the present demand.

Nepal is one of the least developed countries in the world where about one third of its population faces food insecurity and agriculture is primarily characterized to be of subsistence in nature (Nepal, Budhathoki, & Gurung, 2011). Thus, the obligation of maintaining or increasing the production remains very high. Although organic production is generally considered to be lower and is difficult to maintain its integrity by complying with various norms (Trewavas A. , 2002; Meisner, 2007), some argue that enough use of inputs can result in better production (Leu, 2011; Brandt, 2007). On the other hand, even though larger share of labor force is directed more towards this sector, the migration rate is equally high both within (rural to urban) and outside the country (ILO, 2010), which may act as a hurdle for this labor intensive farming method.

1.3 Study rationale

Organic farming in Nepal is still in its initial stage as characterized by various literatures that it lacks proper data, market information and research based activities (Bhatta, Doppler, & KC, 2009; Pokhrel & Pant, 2009). Government has been modestly active in a sense that it has limited its role to raising awareness and conducting training programs in few areas. Non-governmental organizations (NGOs) and few private sectors are providing technical support to some extent but the complete absence of professional institution has further obstructed its development. Few studies conducted in this area are mostly related to perception from various stakeholders regarding different facets of organic farming. But study on impact of organic farming at household level is lacking (Bhatta, 2010) which has a huge significance on its long-term adoption as without any benefit to farmers, its growth cannot be certain.

Moreover, benefit of organic farming itself is highly subjective. Its advantage to a society is perceived on environmental, economic or social grounds, either in isolation or collectively. For instance, SEKEM initiative, which started its first farm on biodynamic methods on 24 hectares (ha) in the desert of Egypt 30 years ago, now has an organic certified area increased to almost 20 ha with another 20 ha in transition. Going organic has helped utilize rice straw which farmers usually burn, to make microbial compost, thus replacing mineral fertilizers. This has reduced emission of carbon dioxide, nitrous oxide and methane gases thereby increasing air quality. The economic liberalization policy and increased exports to the international market led farmers to rely on biological fertilizers instead of chemical fertilizer. A research showed organic agriculture significantly lowered nitrate-leaching rates per ha, lessening the pollution in drinking water. The use of chemical pesticides reduced from 30,000 tons annually in the early 1990s to around 3,000 tons in 2007. With better food quality, increasing awareness and health consciousness, consumers' willingness to pay increased. Farmers too showed satisfaction due to significant reduction in health problems (Brandt, 2007). A more comprehensive detail on results from numerous studies has been compiled by Leu (2011) in a scientific study that validates organic method to be the low cost, high yielding, both environmentally and economically profitable endeavor. It has been claimed that even after introducing conventional agriculture, food production per person in Africa decreased by 10 percent compared to 1960s level; and the United National Conference on Trade and Development (UNCTAD) and the United Nations Environment Programme (UNEP) found that organic agriculture can boost yields in Africa with crop yield increasing as much as 116 per cent for all African projects. In Madhya Pradesh, India, farmers had to face declining returns, toxicity and severe pest problem despite increase in pesticide use, due to which many abandoned cotton production altogether. Then what started as an experimental plot for organic cotton farming, after seven years more than one thousand farmers were cultivating in more than 15,000 acres with cotton yields increasing up to 20% more than in neighboring conventional farms. Faced with similar problems, in Peru too organic cotton yielded 10-20% higher than the national average in the arid coastal plain (Parrott & Marsden, 2002). A similar result in China also showed improvement in food security in terms of nutrition and quantity, optimization of the agricultural structure and ensuring profit for both farmers and the company involved for organic vegetable production, processing and trading (Brandt, 2007). Thus, any judgment towards feasibility of organic farming in a given society and ways to overcome the barriers for expansion of this sector should be context specific.

When we discuss about the reliability of organic or conventional farming method; various social, economic and environmental issues come into play that determines its compatibility. Economic benefit is the top most priority for smallholder farmers but over a period of time, environmental and social sustainability plays an equally important part. Thus, there is a need to assess any method from these three aspects for a long-run sustainability. With this realization, there should be studies that tries to do an in-depth analysis of organic farming and at the same time compare it with conventional farming so as to understand which kind of farming method best fits the local situation at the present context. Even if organic farming were to be promoted on theoretical grounds, we need to know what steps should be taken to expand and sustain it overtime. Especially for a least developed country like Nepal, which faces incidences of food insecurity, climate change and increasing expensiveness of agro-chemicals and pesticides, it is necessary to realize how organic farming materializes to deal with above mentioned issues.

1.4 Study objectives

The general objective of this study is to explore nature of organic and conventional farming method in the study areas. In doing so, it also compares between these two farming methods in terms of two aspects of sustainability; economic and environmental, to identify and propose a solution for the long-term viability of organic farming for sustainable food production method.

To deal with the above-mentioned general objective, this study specifies five specific objectives, which are mentioned below:

i. To determine various livelihood assets impacting adoption of organic and conventional farming method

ii. To analyze nature of crop diversity in organic and conventional farming method and factors contributing to such diversity

iii. To assess organic means of crop management practices in organic and conventional farming method and factors determining such adoption

iv. To evaluate farm income and gross farm cash income in organic and conventional farming method and factors influencing such income

v. To assess production and net return from carrot production in organic and conventional farming method and its influencing factors

1.5 Study limitations

In the study areas, the group has been formed for the purpose of organic farming, which has been conducting all sorts of trainings and other related activities starting from the year 2005. The recognition gained throughout these years by farmers is enormous. The study area is well known among organic enthusiasts for being one of the actively engaging groups when it comes to organic farming. Various stakeholders such as delegates, teachers, government and non-government officers, students, tourists, journalists, researchers, farmers, etc. regularly visit this area to examine and learn more about organic farming. As a result, farmers are also getting various advantages from these stakeholders. Especially few NGOs are highly actively in providing trainings and other assistances in the form of seed, financial aid for adopting new technologies and so forth. The organic farm has been certified twice since its initiation and this would not have been possible without the financial waive or support from certifiers and private organization. Again these organizations are attracted to the study areas because of group conversion, which certainly lowers the cost in their attempt of certifying or marketing. Because of various tangible and intangible benefits that farmers have been receiving, sometimes they hesitate to tell the truth if they have sometimes used chemical inputs. Understandably so, organic means of farming is known for being difficult in containing pests, diseases and weeds. Without readily available solution or resources, it is not their fault that they have to rely on such chemical inputs in the fear of losing their production for household food security and to increase farm income. To overcome the intrinsic biases, this study tries to triangulate data in best possible way to determine the actual organic farmers by cross-interviewing the farmers themselves and designing questionnaire in such a way, which requires them to identify the inputs they have used. Even though there might be some errors because of hesitancy among farmers during the time of the survey, we cannot imply that all organic farmers identified in this study have used restricted inputs. This can be because of their access to organically viable inputs such as seeds or their self-desire to do natural ways of farming for healthy living. Nevertheless, this study tries to shed light on constraints of organic farming as faced by farmers, which is more important.

In the process of analyzing sustainability of organic and conventional farming, the study has narrowed down its scope limiting to only environmental and economic sustainability. Social sustainability is also an important aspect, which has been largely excluded in this study. An attempt was made to analyze the health impact on farmers as a result of coming in contact with agro-chemicals while using them in the field or consuming food with pesticide residues to relate it with social sustainability aspect of this farming method. However, other than the temporary health impacts as a result of coming in contact with chemical pesticides, the long-term impact could not be verified. Similarly in the absence of soil analysis data, environmental sustainability is measured indirectly by considering ecological indicators such as adoption of various organic means of crop management practices which are known to improve and maintain soil fertility or at least do not have any detrimental impact.

The other limitation of this study is the geographical constraint due to limitation of time and resources. Because the study was conducted in one district, that too in three adjoining VDCs, the result cannot be extended for organic farmers in other parts of the country. Lastly, like in many regression analysis, the econometric models used in this study may also be criticized of excluding several explanatory variables deemed to be relevant in parameter estimation due to dearth of data.

Chapter 2. Literature review

2.1 Organic farming in the global context and in South Asia

According to the survey by International Federation of Organic Agriculture Movements (IFOAM) and Research Institute of Organic Agriculture (FiBL), the area under organic farming and market share has been increasing gradually throughout the world. By 2013, 170 countries were formally involved in this sector through complying with certain standard and managed by almost 2 million producers. An area under organic management reached 43.1 million ha or 0.98% of the total agricultural land, an increase of 66% in more than a decade. This can be attributed mainly to the increase in geographical coverage of the data collection (170 countries in 2013 compared to just 110 countries in 2003). The actual depiction of its growth may be seen from its global sales, which reached US$ 72 billion in 2013, an increase of 188% compared to more than a decade earlier (FiBL & IFOAM, 2005; FiBL & IFOAM, 2015). Thus, it can be implied that organic farming is an emerging sector and has been growing progressively. Oceania (40.2%) is the largest holder of organic agricultural land followed by Europe (26.6%), Latin America (15.3%), Asia (8%), North America (7.1%) and finally Africa (2.8%) (FiBL & IFOAM, 2015). In 2012, Asia comprised 9% (3.2 million ha) of global organic agricultural land. It is about 0.2% of the total agricultural land within the region. Around 36% (0.7 million) of the world's organic producers are in Asia. Within Asia, China has the largest area (1.9 million ha) under organic management, Timor-Leste has the highest proportion of organic agricultural land (almost 7%) and India leads by the number of organic producers (600,000 producers) (FiBL & IFOAM, 2014).

South Asian region comprises of eight countries, viz., Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka (Figure 2.1). South Asia is one of the least developed regions in the world. With a population of 1.4 billion, it accounts for half of the world's poor. Countries like Afghanistan, Bangladesh and Nepal fall under lower income group; Bhutan, India, Pakistan and Sri Lanka under lower middle income group; and only Maldives is considered to be in upper middle income group (World Bank, 2014). Agriculture is an important economic sector and still a large portion of its population is dependent on it for their livelihood (accounting for 30% GDP and 80% labor force in Afghanistan (Kawasaki, Watanabe, Suzuki, Nishimaki, & Takahashi, 2012), 20% GDP and 52% labor force in Bangladesh (Thomas, et al., 2013), 16.8% GDP and 60% labor force in Bhutan (National Statistics Bureau, 2012), 14% GDP and 60% labor force in India (BIOFACH, 2014a), 3.99% GDP and 11.5% labor force in Maldives (Quandl, 2014), 35% GDP and 65% labor force in Nepal (MoE, 2011), 21.4% GDP and 45% labor force in Pakistan (Farooq, 2013) and 13% GDP and 33% labor force in Sri Lanka (Chintana, 2010). South Asia accounts for 1.59% of the global organic share (565,264 ha) and 17.67% within the region (except Maldives due to absence of data). Table 2.1 shows the current status of organic farming in South Asia. However the data does not represent the true scenario as gathering information from informal sector is very challenging and is not easily available.

Figure 2.1 Map of South Asia
Source: World Bank (2014)

Table 2.1 Organic farming in South Asia

South Asian countries	Year 2012			
	Organic (including in-conversion) agricultural land (in ha)	**Share of organic agricultural land by country**	**Number of producers**	**Regulation on OA**
Afghanistan	61	0.0002%	264	-
Bangladesh	6860	0.07%	9337	In process of drafting
Bhutan	6156	1.21%	-	Fully implemented
India	500000	0.28%	600000	Fully implemented
Maldives	-	-	-	-
Nepal	10273	0.12%	247	In process of drafting
Pakistan	22397	0.09%	105	In process of drafting
Sri Lanka	19517	0.75%	404	-

Note: Some country data are missing and thus it does not depict the complete picture
Source: (FiBL & IFOAM, 2014)

India is by far the most developed country in terms of organic farming in South Asia. Along with the highest number of producers, India also has the largest area under organic (500000 ha) within South Asia. India is one of the key global producers of organic cereal (100.5 million ha), citrus (0.75 million ha), temperate, tropical and sub-tropical fruits, oilseeds, protein crop (28 million ha) and vegetables. It is also claimed that cropland area is highly under reported in India, which brings us to assume that it should be much larger than currently stated. Participatory Guarantee Method (PGS) is a locally-driven quality assurance method based on trust, networks, active participation and knowledge exchange; and India again has highest number of (5,977) producers making it one of the largest countries to follow PGS in the world (FiBL & IFOAM, 2014; IFOAMb, 2014). The national PGS council was formed in 2007. Although PGS under organic farming is not recognized by the Indian legislation but in the wake of voluntary organic regulation in the domestic market, it does allow organic claims for uncertified products through PGS certification only (FiBL &

IFOAM, 2012). India is well ahead in terms of formal certification as well. The regulation on organic farming has also been fully implemented. India is one of those few countries whose accreditation procedure is accepted by United States and European Union method (FiBL & IFOAM, 2014). India is also among few countries where most number of certification bodies exists (FiBL & IFOAM, 2013). Government initiated accreditation programme for certification bodies instituted by National Programme for Organic Production (NPOP) are duly recognized by most countries at par with other global organic products as well (Singh B. , 2013).

In India, though Ministry of Commerce launched the National Organic Programme in 2000 as a result of detrimental impacts of Green Revolution resulting in declining soil fertility and pest immunity, requiring higher amount of fertilizer and pesticide use; organic industry is almost entirely export oriented wherein majority of farmers are opting for organic because of the economic benefit rather than for sustainability (Pandey & Singh, 2012). According to Agricultural and Processed Food Products Export Development Authority (APEDA, 2011), India's export of certified organic products grew by 33% from previous year to reach US$ 157.22 billion. India produces variety of organic products with 1,000 certified products to its credit. It has the potential to supply all categories of organic products in an international market. Being one of the important players in global organic market, it has also been dubbed as the fastest growing organic food market in the world. The government is actively promoting organic sector with financial assistance to organic farmers. Government's organic friendly policy has also induced private sectors to be involved through farming, certification, processing, retailing, exporting and bringing in new innovation to sell (Singh B. , 2013).

Domestic organic market is also growing rapidly at the rate of 30–40% annually. It is all attributed to rising disposable income and health consciousness among urban dwellers. India Organic Trade Fair, organized annually by the International Competence Centre for Organic Farming (ICCOA) has helped substantially for developing the local organic market. Including hypermarket, organic produces can also be seen in retail shops which devote separate shelve for organic products, producer-owned stores, informal *haats* (rural market), online stores, etc. Few labels such as Bio Suisse are also encouraging to minimize food miles by rejecting transportation via plane (Kilcher, Eisenring, & Menon, 2008; Singh B. , 2013) due to its relatively high level of carbon dioxide (CO_2) emissions (Gibbon, 2009). The substantial increment in market demand for organic food comes from the mega-cities such as Mumbai, Delhi, Chennai, Bangalore, Gurgaon and Pune where people are getting more affluent and simultaneously have become more health conscious (BIOFACH, 2014b; BIOFACH, 2014a).

Despite such level of development, organic sector is not free from the perils. Area under organic cultivation decreased to 0.78 million ha in 2010 due to spread of BT cotton (bacterium Bacillus Thuringiensis, a genetically modified variety of cotton) and non-availability of non-BT seeds. Large farmers' groups were rejected for certification because of the contamination. In addition to that, unfavorable organic cotton price and termination of state backed certification support schemes resulted in farmers discarding certification renewal. APEDA also implemented mandatory web based certification data management method or online traceability scheme called TRACENET since 2012 which proved to be a hassle and discouragement for many farmers (FiBL & IFOAM, 2012).

Organic sector in other South Asian countries is also promising, both as an export and in local market. In case of Bangladesh, though organic market is still in a growing stage with only limited outlets selling on limited scale, the number of producers and companies advertising their products as organic are ever increasing. Although authenticity of such claim is debatable as organic labeling is not regulated. Bangladesh Organic Products Manufacturers Association (BOPMA) came up with its own standard by establishing a certification body named Organic Bangladesh Limited. BOPMA is also actively involved in uplifting this sector through training farmers, producing fertilizer and pesticides and is on the verge of establishing number of outlets. Government provides incentive to private exporters for exporting goods, supports entrepreneurs, boosts technology adoption and work towards food safety related complications. Different organizations are carrying out research but without proper coordination. In Bangladesh, organic products are sold through various ways; special section in many conventional stores, contract farming, direct sales from farmers at local market and urban outlets of Bangladesh Agricultural Development Cooperation (BADC), but it is still not able to cater fully to the domestic demand (FiBL & IFOAM, 2014).

Moreover, most of the organic shops are limited in the capital city, Dhaka. Excluding the special eco-friendly outlets run by an NGO, there are very few shops where organic items are sold in a corner along with other traditional food items. It faces problem of lack of trust among consumers for the uncertified self-claimed organic products (Sarker & Itohara, 2008). Nevertheless, local demand for organic products is growing with increasing awareness among consumers. However, the production and marketing method of organic products based on contract farming by private organizations, companies or chain shops have reduced price received by farmers (Hoque, 2012).

The rise in local demand is accredited to food safety and environmental concerns. Organizations such as Horticulture Export Development (HORTEX) Foundation is also working towards providing service on production, post-harvest management, certification and marketing for local and export market (HORTEX, n.d.). Bangladesh has a huge organic aquaculture land accounting for 28% of 33,800 ha area available globally. Besides India, it is also producing organic Black Tiger (shrimp). At present it exports tea, shrimp, and some herbal and medicinal products on a limited scale but has so much more potential. The major areas to be considered are production, supply chain, information on import and export, and developing national policy, standard, inspection, and certification method for organic products (FiBL & IFOAM, 2014).

Bhutan is another unique example, which caused a worldwide stir by claiming that it intends to make the whole nation organic by 2020. With this intention, Bhutan National Organic Program (BNOP) is also giving support through training, seeds, seedlings, and soil fertility improvement techniques. Though support from government is high, human resources and technical facility are limiting factors (FiBL & IFOAM, 2013). Another challenge is farther distance to market from rural areas, which discourages farmers to sell their produce (Katwal, n.d.). Currently few of the products are exported and few organic retails shops are situated in the capital (Dorji, 1999). Organic produce is perceived to generate better revenue for farmers and alleviate poverty. One of the major cash crops, red rice is produced in high altitude of Bhutan and is claimed as a natural product (without certification). It is exported to USA and Europe, especially Germany and the United Kingdom with around 100 metric tons annually with a good profit margin (Duba, Ghimiray, & Gurung, 2008; Agrifood Consulting International, 2007). However, demand is considered to be around 200 metric tons and it has not been able to meet the target fully because of scattered nature of production, low yields, absence of certification method and the need for documentation (Agrifood Consulting International, 2007). Bio Bhutan, a private enterprise, has successfully opened niche markets in Asia, Europe and the United States for organic certified lemongrass oil with premium price (Yangzom, Krug, Tshomo, & Setboonsarng, 2008), which is Bhutan's only organic certified product (Agrifood Consulting International, 2007). Bhutan has the highest share of organic to overall agricultural area (1.21%) within South Asia. Besides India, it is the only other country in South Asia that has fully implemented the regulation on organic farming. Nevertheless, it is still a huge challenge to realize its vision of going 100% organic (FiBL & IFOAM, 2014).

Sri Lanka have also established government competent organic labeling regulation (FiBL & IFOAM, 2010) and joined collaboration of private and government linked certification bodies for low cost inspection and certification under the label of Certification Alliance (CertAll) (FiBL & IFOAM, 2011). In Sri Lanka too, claims of organic to get advantage of the growing market have been emerging. Tea, coffee, spices and fruits are well developed than others commodities in this country. Government support remains contradictory where promotion of organic manures encouraged some to adopt but chemical fertilizer subsidy discouraged others to convert to organic. Certification for export and development of new markets have emerged in the light of food contamination issue but still awareness on organic remains low (FiBL & IFOAM, 2013). Pakistan, on the other hand, faces threat of losing many international markets after the introduction of World Trade Organization (WTO). Currently it exports fruits mainly to Middle East, Sri Lanka and Central Russian States, where quality standards are not as rigorous as in the developed countries. Therefore, it has decided to introduce Euro Good Agricultural Practice (Euro GAP) for improving its farming standards applicable to international standards (Farooqi, 2007). Unfortunately, specialized market for organics does not exist at this moment, which means that organic farmers are not benefited through better returns (Mehmood, Anjum, & Ahmad, 2011). (Organic farming in Nepalese context is presented in Section 2.3 below).

Overall, Asian countries are known to be mainly export-geared. In case of South Asia, countries like India and Sri Lanka have highly export-oriented organic sectors. Though there is dearth of information on local and export market for most of the countries, specifically Afghanistan, Maldives and even Pakistan; the overall trend of organic sector is seen to be on rise in national market as well due to increasing income and growing awareness of health benefits from consuming organic products (FiBL & IFOAM, 2014).

2.2 Rewards and perils of developing countries being integrated into global organic market

Although organic sector is growing in both developing and developed countries, whether it is production or consumption oriented varies significantly among the countries or regions depending on the purpose the sector is built on. Currently North America and Europe are the regions with high concentration of market for organic products. Within Asia also market for organic is more confined in affluent countries such as Japan while others have export-oriented sectors (Figure 2.2) (FiBL & IFOAM, 2014). Due to concentration of organic market in economically better off areas of the world, the word 'organic' often holds a connotation of rich man's food as it is usually more expensive than conventional food (Belicka, 2005; FAO, 2014).

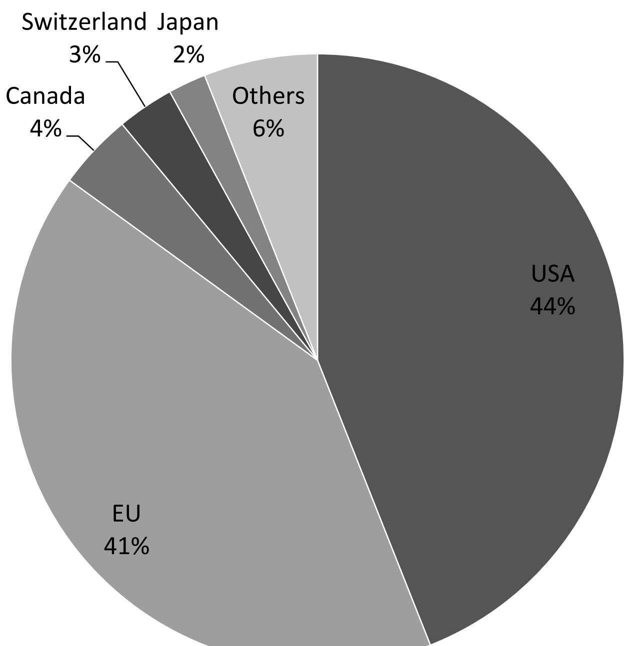

Figure 2.2 Global market for organic food in 2012
Source: (FiBL & IFOAM, 2014)

The prospect of higher income has persuaded developing countries to take part in global organic market. Usually they join in fair trade arrangement through consolidation with importing countries. Even then smallholder farmers in developing countries can face numerous difficulties in the way of lack of adequate financing, management skills, consistency in workforce, logistics, partnership and cooperation, and cultural differences as a result of globalization (Halberg, Alroe, Knudsen, & Kristensen, 2006). On the one hand, certification does help farmers to integrate into global premium market for organic. But such globally uniform standards, which are usually imposed by developed or importing countries in the North on the developing or exporting countries in the South, might not actually blend with the conditions in the South. For example, there is restriction to use neem only in the roots of mother plants according to European Union standard. But in tropical countries where pests can multiply at an alarming rate, it becomes necessary to use them as pesticides in a way that may violate the rule. Obtaining and maintaining internationally recognized standards, high level of record keeping, delay in procuring certification, cost of certification and annual re-inspection are other major obstacles for smallholder farmers. Because of this, often times such standards and control method rather obstructs the potential growth and spread of organic sector (Halberg, Alroe, Knudsen, & Kristensen, 2006; Barrett, Browne, Harris, & Cadoret, 2002; Harris, Browne, Barrett, & Cadoret, 2001).

Moreover, global organic food market is facing a greater risk of following the footsteps of conventional model characterized by specialization, capital intensification, export orientation, increased processing, packaging and long-distance transporting that is controlled by few large corporate retailers. Specialization and capital intensification reduces diversity, increases risk of a single crop failure and limits natural nutrient cycling processes, which could have been achieved through multiple/intercropping method. Market concentration increases vulnerability among farmers in case of price fluctuation or market failure. More so, when it is in the hands of few retailers, there is a price monopoly and farmers would no longer have control over price. The growing distance of trade, especially from South to North where developing countries like Brazil, Egypt and Uganda are now exporting to Europe and North America, has increased ecological footprints as well (Halberg, Alroe, Knudsen, & Kristensen, 2006; Kilcher, Eisenring, & Menon, 2008; Knudsen, 2010). Thus, commercialization of organic farming has jeopardized the very fundamental elements of organic movement, which is to be self-sufficient and preserve the environmental integrity.

Besides the formal organic market with huge discrepancy between countries (primarily developed versus developing), there is still a large share of unaccounted organic areas, which prevails mainly in developing countries. Because it takes place outside the formalized market method, it is difficult to quantify its extent. Though not certified, it can fetch higher price based on consumers' willingness-to-pay in a local market, besides providing with other benefits of increase in productivity, saving on purchase of external inputs and transport cost, and getting up-close with the consumers (FAO, 2014; Halberg, Alroe, Knudsen, & Kristensen, 2006).

2.3 Organic farming in Nepalese context

The history of organic farming in Nepal is relatively shorter (Bhatta, Doppler, & KC, 2009). It is said that the organic movement in Nepal was initiated in 1986 by Institute for Sustainable Agriculture Nepal (INSAN) (Nepal, 2011; Sharma, 2005). Chemical pesticide application was also initiated late as fertilizer was not known in Nepal until early fifties. However, systematic channel for importing and distributing fertilizer began with the set-up of Agriculture Input Corporation in 1966. Its usage significantly increased with the implementation of Fertilizer Deregulation Policy 1997 by involving private sector in fertilizer trade and National Fertilizer Policy 2002. In Nepal, unbalanced use of fertilizer is rampant that has increased soil acidity, and deteriorated soil physical condition and underground water quality (Shrestha R. K., 2010). Besides that it has also resulted in environmental pollution, increased pest resistance, revived new plant pests, degraded forest area, intensified flooding, erosion, drought and declined overall productivity of major food commodities (Bhatta, 2010; KC, 2006). Now the importance of sustainability in farming has been realized and as a part of which organic farming has been getting special consideration.

The potentiality of organic farming in Nepal has been mentioned in numerous literatures. Although in high mountain and middle mountain areas farmers still rely on traditional knowledge and locally available resources and are largely claimed as 'organic by default' (Pokhrel & Pant, 2009). In figure, more than 70% of the crops are estimated to be cultivated without using chemical fertilizer and pesticide in Nepal (KC, 2006). Thus, it would not take much of an effort to convert their farm into organic and by introducing organic principles the production can further be boosted by enhancing soil structure and fertility through nitrogen fixing legume crops, improving composting techniques and practicing self-made bio-fertilizer and bio-pesticides. Besides that, ecological richness has given Nepal with another advantage of producing quality organic fruits, vegetables, tea, coffee, cardamom, vegetable seeds, mushroom, honey and medicinal plants and herbs. Like other countries, Nepal is also experiencing its share of growth in organic sector. Some of the organic products like tea, coffee, honey, large cardamom, ginger and medicinal herbs are already exported as well (Pokhrel & Pant, 2009; DoAE, 2006; Tamang, Dhital, & Acharya, 2011). The key export market for Nepal is Japan, South Korea and India (FiBL & IFOAM, 2010). Nepal is known for producing organic oil seeds (FiBL & IFOAM, 2013; IFOAMb, 2014). It has the second highest (46%) share of organic coffee.

After Nepal became a member of WTO, it has further increased the prospect in international market as 'organic produce' is identified as potential export crop (Bhandari, 2006; Pant, 2006). The domestic market is also on rise with some existing even on mountain tops and the price can range from 10% to 200% more than conventional products depending on the market location, quality and the product itself (FiBL & IFOAM, 2009). Diversity of market channels such as ad hoc organic bazaars, small retail outlets, supermarket corners, multi-level direct selling and internet marketing are thriving even from rural Nepalese markets (FiBL & IFOAM, 2010).

2.4 Role of government and non-government organizations for the development of organic sector in Nepal

Government support for organic farming has been growing gradually in Nepal even though emphasis on chemical fertilizers to improve agricultural production is more evident. The 20-year APP emphasized on environment protection through farming activities (NPC, 1995). National Fertilizer Policy of 2002 called attention to both organic and conventional sources of plant nutrients to improve crop productivity. The support from government further materialized in its Tenth Five Year Plan (2002-2007) which stresses on minimizing the use of chemical pesticides, promoting the method of Integrated Pest Management (IPM) and providing consideration to promote organic farming based on the use of organic manure. The National Agricultural Policy of 2004 emphasized to provide support for quality certification for export oriented organic products and minimize negative impact and other environmental problems resulting from the use of agrochemicals, veterinary drugs and hormones; improving production and usage of organic manure, enhancing local participation in the food quality management and regulating use of pesticides.

Three Year Interim Plan of 2007 with due realization of adverse effects on environment and human health due to pesticide and its indiscriminate use on crops, prioritized on developing and disseminating eco-friendly technologies, preserving technologies based on indigenous knowledge and skills, and protecting farmer's right on such knowledge method. Agribusiness Promotion Policy of 2006 also gave special consideration to the agriculture practice that is eco-friendly, enhances environmental protection and reduces pollution such as organic farming. In addition to that it also has policy statement of developing special production zones including organic or pesticide free production area, though a clear strategy for implementation is yet to be formulated. In line with this, the government has enacted several other acts and regulations such as Plant Protection Act (1991), Pesticide Act (1992) and Regulation (1993), Food Act (1966), Consumers' Right Act (1997) and Regulation (1999), and Environmental Protection Act (1996) and Regulation (1997). Overall, the policy implementation is far below what has been stated theoretically (Pant, 2006; Pokhrel & Pant, 2009; NPC, 2007).

Most importantly it has also passed the bill for 'National Standards of Organic Agriculture Production and Processing, 2064 (2007)' which follows the definition of organic farming as given by IFOAM 2002 Basic Standards (as cited in FAO, 2002) as follows:

> Organic agriculture is a whole system approach based upon a set of processes resulting in a sustainable ecosystem, safe food, good nutrition, animal welfare and social justice. Organic production therefore is more than a system of production that includes or excludes certain inputs. ("The Primary Goal of Organic," para. 1)

Nepal has established government competent organic labeling regulations and has a single domestic certification body (FiBL & IFOAM, 2010). It has also adopted inspection and certification method under CertAll (FiBL & IFOAM, 2011). Other kinds of promotional activities could also be observed. National association for PGS was formed in Nepal. The government also collaborated with private sectors to develop working guidelines for an Internal Control Method (ICS), PGS and National Accreditation Method. ICS is yet another low-cost quality assurance method that allows for an external certification body to do periodic inspection of individual group members which means that the third party certification bodies only needs to check if this method has been performing well and do few other re-inspections. The government also supported this sector by providing 50% subsidy for capital investment on compost production and 25% on organic manure price. Exporters too received support for certification cost. Government officers are trained for organic farming extension, inspection and certification for organic products (FiBL & IFOAM, 2013; IFOAM, 2014b). The National Organic Agriculture Accreditation Body (NOAAB) of Nepal required national and international certification bodies to apply for accreditation to work in the country which means that foreign certification bodies will soon be monitored and managed more properly (FiBL & IFOAM, 2014). So far it is known to have more than 80 NGOs and private-sector organizations involved in promoting organic farming, particularly in peri-urban areas of the country (Ghimire M. , 2005).

2.5 Organic farming in response to climate change in Nepal

Climate change is a global issue and it is indeed changing at a faster pace. According to Intergovernmental Panel on Climate Change (2007), since 1850 when the instrumental record of global surface temperature began, eleven of the last twelve years (1995-2006) were among the warmest years. Impact of climate change is clearly evident from increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level. The primary cause of such rapid change has been attributed mainly to anthropogenic activities. CO_2 concentration is a result of fossil fuel use and land use change, while methane (CH_4) and nitrous oxide (N_2O) are primarily due to agriculture practice. In the year 1994/95 Nepal was responsible for 9,747 greenhouse gas (GHG), 948 GHG, and 31 GHG of CO_2, CH_4 and N_2O gases, respectively. The major sources of emission were from enteric fermentation (28% of the total CO_2

equivalent) and agricultural soils (21.3%) followed by land use change and forestry sector, rice cultivation, biomass burnt for energy, manure management and municipal solid waste disposal. When it comes to Nepal's share of per capita CO_2 equivalent emission, it remains below 2 tonnes, which is almost half as compared to global average value of 3.9 tonnes per capita. The annual compound growth rate of CO_2 equivalent emissions from Nepal is 2% per annum, which is lower than that of any developing countries. Nepal has always been vulnerable to climate variability and global warming has further exacerbated its level of exposure. In a recent global risk index of the most vulnerable countries in the world, it is ranked fourth in the context of climate change and is mainly contributed to its more than 80% area being fragile ecosystem and having low per capita income. The adverse impact of climate change is already evident in water resources and agriculture and is likely to affect land use and land cover, biodiversity, eco-systems, human health and livelihood method. The increasing intensity and frequency of flood, hailstones, landslides, soil erosion, drought, crop diseases, and increased temperature and varying precipitation pattern due to climate change has exacerbated the production loss (MoE, 2011).

Agriculture thus being one of the major sources and taker of climate change, a more sustainable practice should be adopted which can blend with both of these aspects. Organic farming is one way to fulfill this requirement as it emits much lower level of greenhouse gases, and is known to quickly, affordably and effectively sequester carbon in the soil. In addition to mitigating climate change its other features like water efficiency, resilience to extreme weather events and lower risk of complete crop failure makes it one of the effective ways to adapt to changing climate in agriculture sector. Given that soil is the major storage of carbon and that it accounted for a tenth of anthropogenic CO_2 emission since 1850, a change in agricultural practice to organic farming can help inverse this trend (IFOAM, 2009).

2.6 Organic farming in response to food insecurity in Nepal

Environmental degradation and food insecurity are the major problems Nepal is facing today. Nepal has a population of more than 26 million with annual growth rate of 1.4 percent (CBS, 2011) and is considered to be one of the poorest countries in the world. Though it has achieved remarkable progress over the last years, about 25 percent of its people are still living on less than US$1.25 a day (World Bank, 2015). Food insecurity largely looms throughout the country. Around 25% of households are considered to have insufficient food consumption to ensure a basic diet. Nearly half of children under five years of age suffer from chronic under nutrition while 15% of children under five years of age is affected by acute under nutrition (CBS, 2013). Therefore, the responsibility to feed its ever-increasing population remains high (Shrestha R. K., 2010). In addition to it, the problem of environmental degradation is getting apparent in agriculture sector. Studies show that land area covered with acidic soil has rose from 36% to 61%; almost 98% of the soil is deficient in organic matter; and the amount of available Nitrogen (N), Phosphorous (P) and Potassium (K) in soil is also decreasing. Additionally more than 10,000 ha of agricultural land in Nepal have already been deserted and although no specific data is available; hardening of soil, drying of water sources; and erosion of agro-biodiversity are frequently experienced by the farmers (Bhatta, 2010).

Food security, as defined by Food and Agriculture Organization of the United Nations (FAO) is the physical and economic access to sufficient, safe and nutritious food which meets the individual's dietary needs and food preferences for an active and healthy life (FAO, 2006). This means that food security not only implies enough food production but also accessibility and not only quantity consumed but the quality as well, for one to remain active and healthy. The four dimensions: availability, accessibility, utilization and stability are the most widely accepted definition of food security. The potential of organic farming to overcome the problem of food insecurity in context of these four dimensions is highly arguable. Some are of the opinion that feeding through organic farming comes with a huge cost of increasing land area and making available enough organically acceptable fertilizer (Trewavas A. , 2002; Meisner, 2007) whereas some have argued from their experiences that it indeed can be a solution to growing food demand and preserving environment, given that proper consideration is taken to fix microbial activities in the soil and intensive natural remedies is followed to boost the production (Leu, 2011; Brandt, 2007). In Nepalese context, it is further argued that chemical fertilizer usage is comparatively lower than in other countries (Vaidya, Shrestha, & Wallander, 2008) and thus will not have much effect on production when changed to organic as loss is higher in areas where chemical has been used intensively before (Zundel & Kilcher, 2007). Besides areas with deteriorated soil or those claimed as 'default organic', production sustainability can only be revived through organic principles. Another advantage of going organic in case of Nepal is it reduces dependency on imported high-cost agriculture inputs and with high labor availability in agriculture sector makes it even ideal situation as organic farming does demand more labor than conventional farming. Most importantly environmental sustainability and improved working and living condition through pesticide free nutritious food are the major benefits of organic farming which can contribute in securing food requirement in a sustainable manner.

Chapter 3. Research design

3.1 Analytical framework

Since the beginning of the 21st century, the term 'sustainability' gained worldwide attention as a result of the extent of environmental damage brought by rapid industrialization and economic growth. The idea of sustainability started getting recognition when International Union for Conservation of Nature (IUCN) in 1969 and United Nations Conference on the Human Environment in Stockholm in 1972 emphasized that economic prosperity is possible without degrading the environment. Over the course, this concept has evolved through the World Conservation Strategy in 1980, the Brundtland Report in 1987, and the United Nations Conference on Environment and Development in Rio in 1992; including other government, non-government and private organizations. Among others, definition by Brundtland Report, which states sustainability as the one that 'meets the needs of the present without compromising the ability of future generations to meet their own needs', remains the most widely accepted one. Though the path to achieve it is vague, it at least gives an acceptable meaning to sustainability in today's context, which is emphasizing on the need to work on environment degradation but at the same time not undermining the importance of economic development (Adams, 2006).

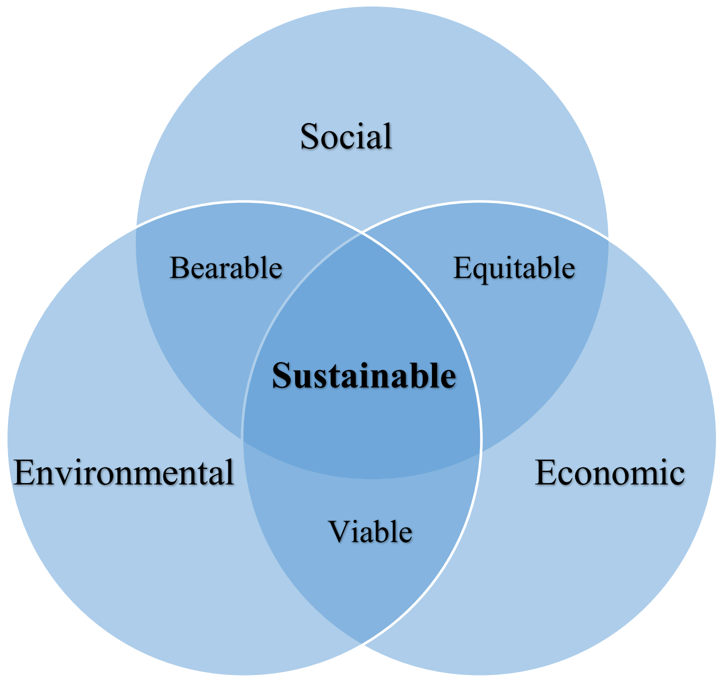

Figure 3.1 Three pillars of sustainability

At present, sustainability is widely viewed from the perspective of social, economic and environmental dimensions (Figure 3.1). Even in the case of agriculture sector, if it has degrading impact on one of these spheres, it cannot sustain over the long term. Social sustainability refers to fairness to all the people involved including farmers and community at large. Economic sustainability is that a farm should give monetary benefit that helps secure farmers' livelihood and others involved too by ensuring food security and being able to access other necessities of life such as education, health and so on. Environmental sustainability means it keeps intact the environmental services provided through soil, water, and air that community relies on for their survival. These three dimensions intersect, impacting and influencing each other either in a constructive or detrimental way. For instance, multiple cropping though provides social benefits through high-nutritional value crops and environmental sustainability through natural nutrient recycling processes, it may result in lower efficiency in economies of scale due to diversity of enterprises (Belicka, 2005; FAO, 2014) and thus might provide less economic incentive. Although certain steps can be taken to improve the outcome through better market mechanism for variety of crops rather than for selected few.

In the field of farming, organic farming is viewed as one of those sustainable approaches which ensures health of both producers and consumers, protects natural environment and brings higher return through premium price and sometimes through higher production as well. Though theoretically it is an ideal way of farming, in reality it faces numerous challenges for a large-scale adoption. Besides, sustainability remains a highly context-specific issue and any discussion of a method complying with all three dimensions of sustainability varies from one area to the next. Understanding intersection between these dimensions is fundamental to both assessment and promotion of sustainability.

Thus, this study tries to analyze sustainability of organic farming in a local context, taking a case study of lowest administrative units of Nepal by mainly focusing on two dimensions of sustainability; environmental and economic. The environmental sustainability is measured by evaluating organic means of crop management practices, since these are the methods to achieve better ecosystem services that help maintain production over time without degrading the environment. Crop management practice is categorized into two groups. The first one is soil fertility management practices under which five practices are identified; mulching, compost-shed, bio-slurry, vermi compost and plastic cover. These practices are known to improve soil fertility overtime, thus sustaining the ability of soil to improve the production (Bista, Ghimire, Shah, & Pande, 2010; Montri & Biernbaum, 2009). The second component is bio-pesticides, which is an organic means of pest management. Although it does not improve soil fertility, it provides a solution to managing pests through organic means, which do not degrade the soil quality (EPA, 2013). And finally economic sustainability, which is probably the most important aspect for farmers especially in developing countries (Ramdhani & Santosa, 2012), is measured by evaluating crop diversity by using Shannon Diversity Index (SHDI) which according to Wilsey and Potvin (2000) is also an indicator of total productivity. Another component of measuring economic viability is farm income, which considers the overall farm output valuation, and gross farm cash income that considers only the cash income as a result of selling crops in the market. The last component of economic return is production and net return of carrot, one of the most commercialized non-staple crops in the study areas. After inspecting from these two dimensions, we will be able to understand the viability of organic farming in a given context, time and place, and identify and propose ways to make this practice sustainable over a long period.

The analytical framework for this study is provided in Figure 3.2. This study refers to five livelihood assets as mentioned by Scoones (1998); physical (such as distance to nearest agrovet and market), social (group membership), financial (farm & non-farm income), natural (livestock holding, farm size, crop diversity), and human (education, primary occupation, farm experience, labor availability, training). All these assets determine the kind of farming method a farmer will adopt which could be organic or conventional. However, the bottom line of such practice should be sustainability. This study evaluates two aspects of sustainability, i.e., environmental and economic. By strengthening the sustainability of a farming method, it will further support or strengthen the livelihood assets of the households.

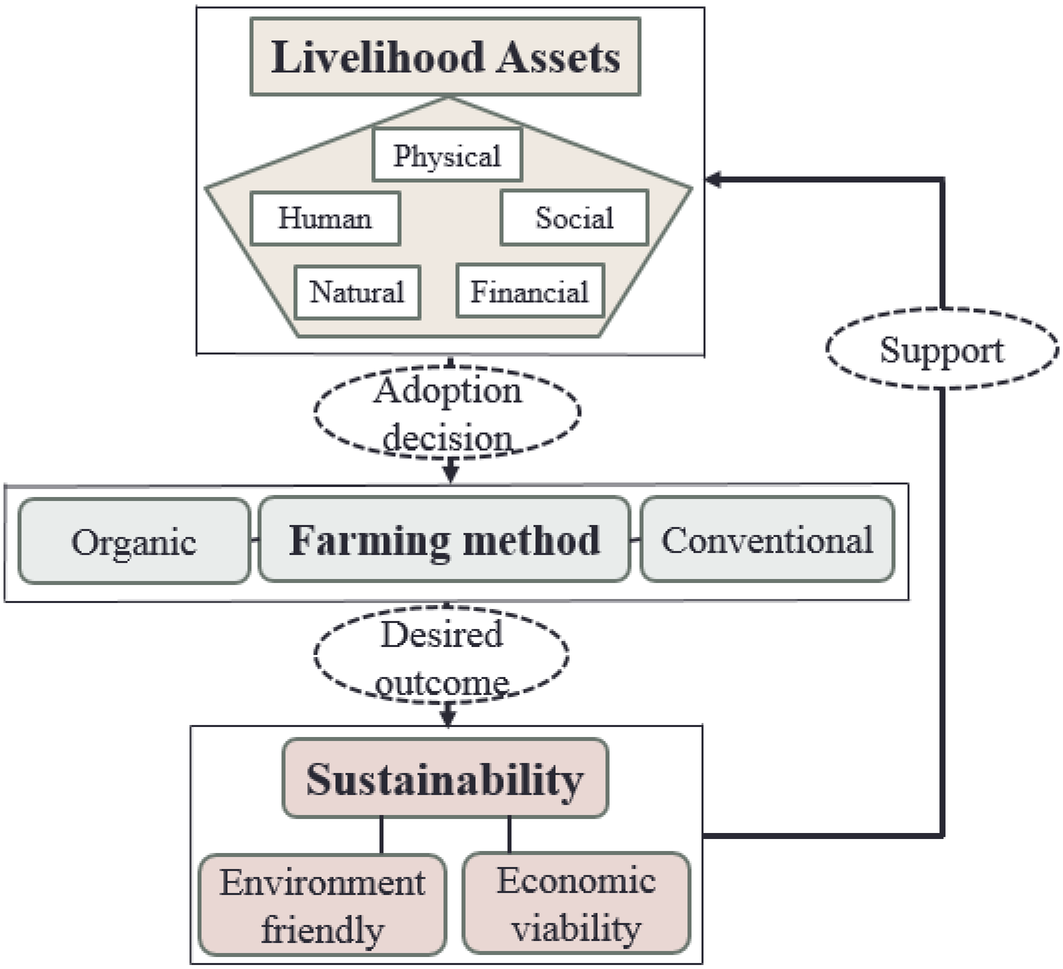

Figure 3.2 Analytical framework of the study

3.2 Study areas

This study was conducted in Chitwan district that lies in the southern part of Central Development Region of Nepal. Geographically, Nepal is divided into three ecological zones and five development regions. The southern part is basically a plain area, also known as Tarai region

(Figure 3.3). With elevation below 300 m, it accounts for 20.1% of the total land area. Even so, 34% of the total cultivable land lies in this part as it has the most fertile soil compared to other parts of the country (FAO, 2013). This lowland Tarai region produces an agricultural surplus, part of which is supplied to other parts of the country and the rest are imported from India and other neighboring countries (SECARD, 2011). Chitwan district lies between 27° 21' 45" to 27° 52' 30" north latitude and 83° 54' 45" to 84° 48' 15" east longitude. It occupies an area of 2,205.9 km^2 and has climate of subtropical monsoon with an average annual rainfall of 2,318 millimeter (mm). It has a high agricultural potential with the most fertile alluvial floodplain land, forest, rivers and lakes in Nepal (Devkota, Budha, & Gupta, 2011). According to MoHP (2011), only 27% of the population in Chitwan district resides in urban areas, which means that the rest 73% of the population live in rural areas where agriculture is the mainstay. Indiscriminate use of agro-chemicals in Chitwan district is very much existent though, resulting in pest resistance towards pesticides, resurgence of new or already eradicated diseases and pests, and other health hazards to people that are not studied well yet (SECARD-Nepal, 2011).

However, in some areas the concept of organic farming has also been emerging, especially in the three adjoining VDCs, namely, Phoolbari, Shivanagar and Mangalpur VDC (Figure 3.4). Previously in Phoolbari VDC, an informal farmers' group was established under District Agriculture Development Office (DADO) to get various agricultural assistance from the government. DADOs have been established in all 75 districts of the country for agriculture related extension services to the agricultural producers. It performs functions of information dissemination on improved farming techniques through the use of various extension methods including demonstration, training, farm visit, agriculture tour, competition, leaflet distribution and meeting (FAO, 2010). Later the group was renamed to reflect its purpose of uplifting organic farming and soon converted into a cooperative named Organic Agriculture Producers' Cooperative Limited.

Amidst this transition, some NGOs (SECARD Nepal, Eco Centre and Action Aid) initiated various organic farming related projects and it was expanded in other two adjoining VDCs as well. Shivanagar VDC consists of one group whereas in Mangalpur VDC, three groups have been formed. All the groups in these two VDCs are informal in nature. Farmers have been receiving training related to organic farming from general to more specific ones such as preparation of bio-fertilizers and pesticides for insect/pest management, market promotion and network development; distributing pamphlets on Plant Health and Clinic Initiative; setting up hoarding boards for raising awareness; developing resource center; operating Farmer's Field School (FFS); technology development and transfer; and other extension services (SECARD-Nepal, 2011). Thus, these three VDCs were chosen as study areas.

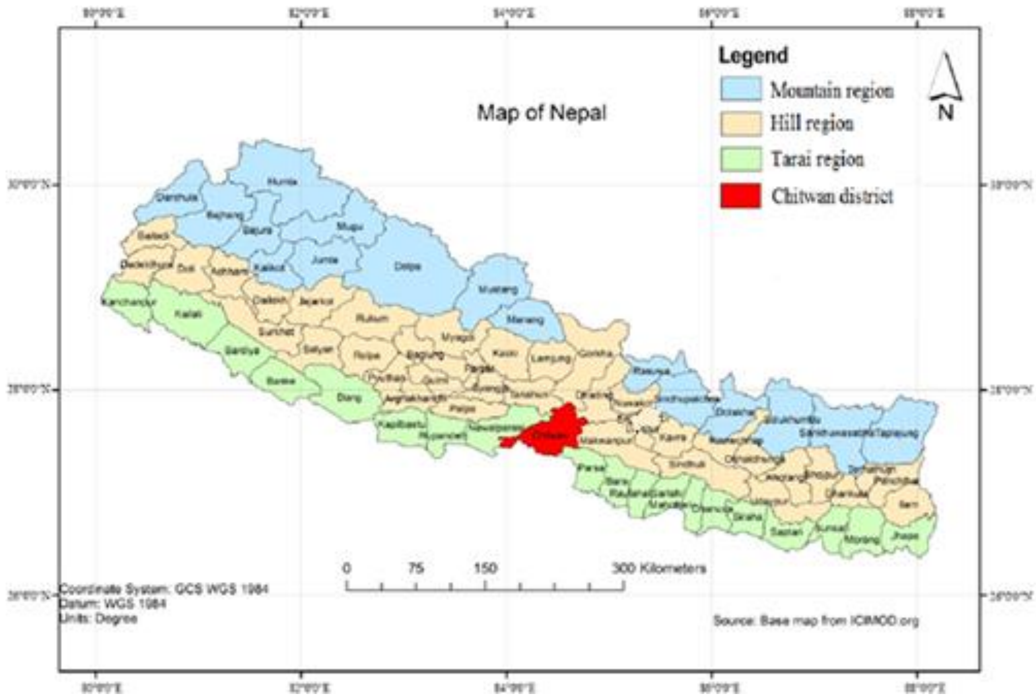

Figure 3.3 Map of Nepal showing study districts
Source: Created by referencing a figure published on ICIMOD.org

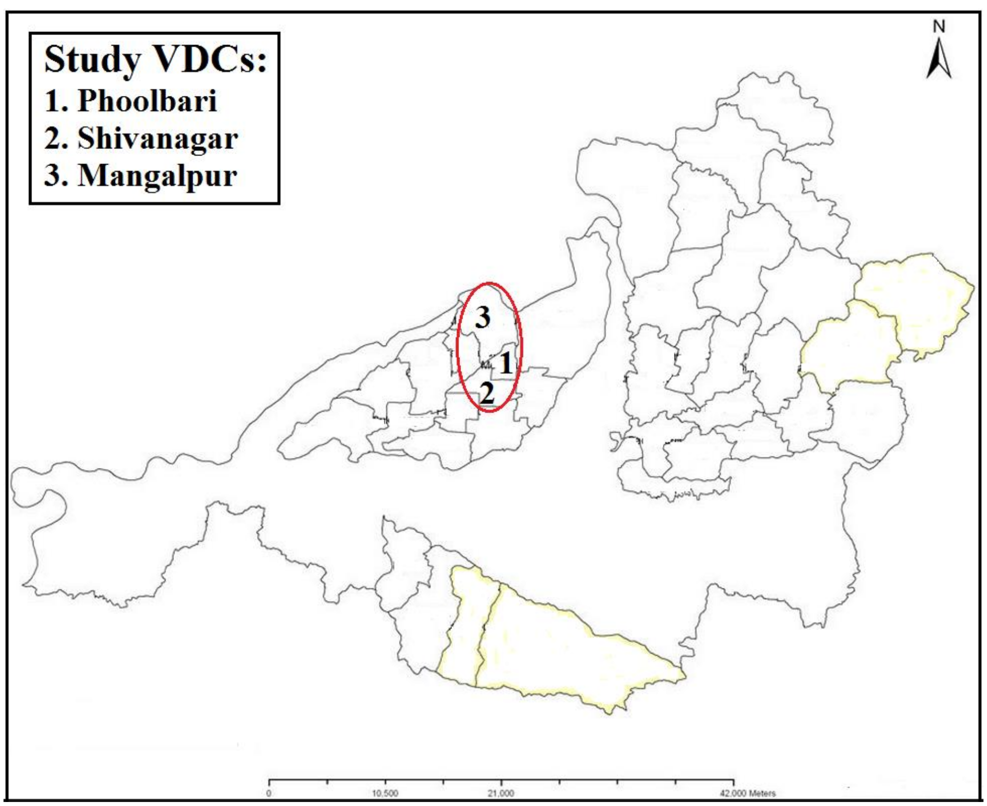

Figure 3.4 Map of Chitwan district showing study areas (VDCs)
Source: Created by referencing a figure published on NEWAH M&E MIS Division as cited in www.newah.org.np/map/Chitwan

3.3 Source of data

The study uses both primary and secondary data collected through individual household survey using semi-structured questionnaire, researcher's observation and participatory methods such as focal group discussions and key-informant interviews. Field visits for data collection were done in two phases. The first phase of field survey to collect household data using small-scale sample survey and to observe first-hand, the status quo of the organic farming was done from February 2013 till March 2013. The follow-up survey to gather additional information through participatory methods such as focal group discussion and key-informant interview was done from October 2014 till November 2014.

For the field survey, competent university students and local people were employed as enumerators, trained properly and monitored on a daily basis by the researcher. Focal group discussions were conducted three times in Phoolbari VDC because of the comparatively higher number of member farmers, once in Shivanagar VDC and again three times in Mangalpur VDC (once for each group established for the purpose of organic farming) to get collective opinions (Appendix I). Key-informant interviews were conducted with representatives from government and non-government officials, certifiers, traders, retailers and local leaders. To supplement the primary data, various published and unpublished secondary sources were also referred such as journal articles, reports, proceedings, scientific papers, books, theses and websites of relevant organizations.

3.4 Sample design

A sample of 300 individual households (initially to choose equal number of organic and conventional farmers) were selected using stratified random sampling method by taking members of a group formed for the purpose of organic farming and non-members as strata who were interviewed through semi-structured questionnaire. Currently a cooperative in Phoolbari VDC has 125 members, an informal group in Shivanagar VDC has 44 members and Mangalpur VDC has a total of 90 members with 30 members in each of the three informal groups. The members of such formed groups thus became our potential respondents, under the hypothesis that all farmers belonging to such group would be organic farmers. However, during the field survey it was realized that not all the farmers belonging to such group are actually practicing organic completely. Likewise, some non-member farmers were also found to be practicing organic farming, which means that organic farming for them was a way of following a practice, which their forefathers used to follow. Thus, in our sample, both organic and conventional farmers simply cannot be identified from their membership status in such groups.

Organic, in this study, implies a farming method in which use of agro-chemical is completely excluded. There are various requirements as laid down by the 'National Standards of Organic Agriculture Production and Processing' for organic farming such as there should be 4 meters distance between an organic and a conventional farm and 5 meters if in case there is a road in between, the water source should be uncontaminated, and so forth. This study simply segregates the farming method based on the use of chemical inputs because such rigorous practice was found to be absent and rightfully so because to follow all the guidelines would take enormous resources. On the other hand, conventional farmers are those who use various chemical inputs. When viewing the nature of conventional farmers, it should be understood that they too do not use chemical fertilizers and pesticides in all of the crops but on the basis of crop-specific requirement. The reasons farmers relied on such inputs are to contain pests, diseases and weeds, and to increase the production. The most common pattern observed was farmer segregating their farmland for organic purpose. This is generally true for vegetable farming which farmers grow organically only for home consumption and is mainly done on a small portion of their land but use chemical fertilizers and pesticides on cereal crops which is rather produced on a larger area. For some it was difficult to grow certain crops, at least during the time of survey, without the use of pesticide. For example, most farmers faced the problem of late blight disease in potato for which using pesticide was inevitable. Other such crops where most of the farmers used pesticides are tomato, kidney bean spinach, cowpea and mustard greens. They used chemical fertilizers mainly for cereal crops like rice, maize, wheat, and oat and even for oil seed crop such as mustard. For others, they choose to grow commercially viable crops like carrot through conventional means for easier management of weeds and pests as well as to intensify production.

An effort was made to select equal number of respondents taking into consideration the group membership but because of restraint by some probable respondents and limited number of organic farmers itself, the final sample out of the total of 300 respondents came out as 32% organic farmers and the rest 68% conventional farmers. Similarly, 50% of the respondents are from Phoolbari VDC and the rest 17% and 32% are from Shivanagar and Mangalpur VDC, respectively (Table 3.1). This sample is based on the number of group members in a particular VDC (48%, 17% and 35% of group members belonged to Phoolbari, Shivanagar and Mangalpur VDC, respectively). Likewise, 47% of the respondents belonged to a group and the rest 53% didn't. The respondents who were interviewed from outside such group were selected randomly based on close geographical proximity with those respondents belonging to a group so as to equalize factors like soil type and local climate for the fair analysis of farm production between these two farming methods in the later chapters. Across the VDCs too, the sample size for member farmers in Phoolbari VDC is higher compared to other two VDCs (Table 3.2). After eliminating the outliers, the final sample of 285 is taken for statistical analysis.

Table 3.1. Distribution of respondents belonging to two farming methods across VDCs and based on group membership

Variables	**Farming methods**		**Total (n=300)**
	Organic (n=95)	**Conventional (n=205)**	
VDCs			
Phoolbari	64 (67.37)	87 (42.44)	151 (50.33)
Shivanagar	15 (15.79)	37 (18.05)	52 (17.33)
Mangalpur	16 (16.84)	81 (39.51)	97 (32.33)
Membership			
Yes	71 (74.74)	69 (33.66)	140 (46.67)
No	24 (25.26)	136 (66.34)	160 (53.33)

Source: Field survey (2013)
Note: Figure in parenthesis indicate column percentage

Table 3.2. Distribution of respondents across VDCs and based on group membership

Membership	**VDCs**			**Total (n=300)**
	Phoolbari (n=151)	**Shivanagar (n=52)**	**Mangalpur (n=97)**	
Yes	83 (54.97)	18 (34.62)	39 (40.21)	140 (46.67)
No	68 (45.03)	34 (65.38)	58 (59.79)	160 (53.33)

Source: Field survey (2013)
Note: Figure in parenthesis indicate column percentage

3.5 Data analysis

Data was analyzed through both descriptive and econometric methods using the Data Analysis and Statistical Software - STATA 13. The descriptive statistical tools are percentage, mean and standard deviation. The econometric tools are bivariate probit, multivariate probit and ordinary least square models. The definition and measurement of selected variables for the purpose of understanding them in the following chapters is given in Table 3.3.

Table 3.3 Definition and measurement of selected variables

Variables	Definition and Measurement
Categorical	
farm_method	Farmers practicing organic farming; 1=yes, 0 otherwise
HHHgender	Male-headed household; 1=yes, 0 otherwise
HHHprimary_occu	Primary occupation of household head (HHH); 1=farming, 0 otherwise
rent	Farmers renting by paying either cash or through crop sharing or mortgaging in farmland; 1=yes, 0 otherwise
membership	Being a member of in/formal group formed for the purpose of organic farming; 1=yes, 0 otherwise
VDC	Belonging to Phoolbari VDC; 1=yes, 0 otherwise
credit	Credit taken for farming related activities; 1=yes, 0 otherwise
final_price	Know price of one or more crops at which it is sold to consumers; 1=yes, 0 otherwise
Discrete	
HHHage	Age of HHH; in years
HHHedu	Education of HHH; in years
org_exp	Experience of practicing organic farming; in years
org_training	Organic farming related training; number of times
Continuous	
LFU	Labor force availability in HH; in Labor force unit (LFU)
LSU	Livestock holding in HH; in Livestock unit (LSU)
farm_size	Operational farm size; in ha
farm_income	Monetary and non-monetary gross value of total production from farming of cereals, vegetables, spices, pulses, oil seeds, fruits, livestock products and byproducts, and occasional income generated from selling trees; in Nepalese Rupees (NRs.)/HH/year
nonfarm_income	Income from non-farm activities such as service, business, rent, remittance, pension and wage laboring; in NRs./HH/year
agrovet	An exclusive store for agriculture related products where agricultural inputs (seeds, fertilizers, pesticides, etc.) and equipment, and livestock such as veterinary medicine could be found; Distance to nearest agrovet (in km)
market	Market for selling agricultural products; Distance to nearest market (in km)
commercialization	Commercialization rate (total quantity of crops sold/total produced)
cash_income	Income from selling crops; in NRs./HH/year
SHDI	Shannon Diversity Index that captures both crop richness and evenness

Source: Field survey (2014)

Chapter 4. Descriptive analysis

Table 4.1 and Table 4.2 deliver the descriptive analysis of 285 respondents' (after removing the outliers) socioeconomic characteristics, which form the basis of various components of their livelihood assets. It is found that only 8% of the households are female-headed which is comprehensible as Nepalese society is mainly patriarchal-based. Head of households (HHHs) are those who are responsible for making key decisions in the family matters. The average age of HHH is 50 years old. Some 7% of HHHs do not have any educational background. In others words, they are illiterate and cannot read or write at all. About 30% of them identified themselves as having only a basic education, which is defined as those who can do simple reading and writing. Some 41% had education till secondary level (formal education of 10th grade and below), 11% had higher secondary education (formal education of 11th and 12th grade), 9% had bachelor's degree and only 3% of them had master's level education. The average years of educational attainment by the respondents is 7 years.

The majority (58%) of HHHs still recognize farming as their primary occupation. Almost 79% of the farmers owned the land they are farming on but 21% of them either rented in for kind or cash, or mortgaged in the farmland in addition to farming their own land. Farmers have been practicing organic farming for about 3 years on average. However since the standard deviation (3.25±7.48) is higher, it means that organic farmers are either the traditional practitioners who have been following the farming method of their forefathers or the new practitioners, most probably as a result of organic farming related activities performed through the group. Labor force unit (LFU) is the standard unit of labor force which takes people aged 14-59, irrespective of their sex, as 1 and those below 14 and above 59 as 0.5. In this study, LFU excludes the household member/s who have migrated whether temporarily or permanently and reflects only those who are available in the household. As a result, the households have 4.28 LFU on average. Likewise, livestock unit (LSU) is a standard way of measuring livestock holding which is calculated as an aggregate of different types of livestock kept at household in a standard unit by taking 1 adult buffalo as 1 LSU, 1 immature buffalo as 0.5 LSU, 1 cow as 0.8 LSU, 1 calf as 0.4 LSU, 1 pig as 0.3 LSU, 1 sheep or goat as 0.2 LSU and 1 poultry as 0.1 LSU (CBS, 2003). In the study areas, about 87% of the households have livestock holding with 2 LSU on average. There is a significant difference across two farming methods with most of the organic farmers having higher livestock holding compared to conventional farmers.

Around 47% of the respondents have a membership in a group formed for the purpose of organic farming and it is significantly different across two farming methods. This shows that being a member of such group does not guarantee that a farmer will indefinitely practice organic farming but it definitely represents having higher number of organic farmers (76% of organic farmers are members compared to just 34% of conventional farmers). Nearly 44% of the respondents have received training related to organic farming. Like membership, it is also significantly different across two farming methods and receiving such training while does not ensure that a farmer will practice organic farming, it definitely has impact on larger share of farmers practicing organic farming. While most of such trainings are provided through such groups, some farmers received it from other sources as well. On average farmers have received such training related to organic farming at least once.

Table 4.1 Descriptive analysis of (categorical) variables across two different farming method

Variables	Farming method		Total (n=285)	P-value
	Organic (n=91)	Conventional (n=194)		
Gender of HHH				
Male	82 (90.11)	180 (92.78)	262 (91.93)	0.440
Female	9 (9.89)	14 (7.22)	23 (8.07)	
Education of HHH				
Illiterate	4 (4.40)	16 (8.25)	20 (7.02)	0.497
Basics	25 (27.47)	60 (30.93)	85 (29.82)	
Secondary and below	38 (41.76)	79 (40.72)	117 (41.05)	
Higher Secondary	10 (10.99)	21 (10.82)	31 (10.88)	
Bachelors	10 (10.99)	15 (7.73)	25 (8.77)	
Masters	4 (4.40)	3 (1.55)	7 (2.46)	
Primary occupation of HHH				
Farming	50 (54.95)	114 (58.76)	164 (57.54)	0.543
Others	41 (45.05)	80 (41.24)	121 (42.46)	
Ownership				
Owned + Lent in	20 (21.98)	41 (21.13)	61 (21.40)	0.871
Owned	71 (78.02)	153 (78.87)	224 (78.60)	
Livestock holding				
Yes	85 (93.41)	164 (84.54)	249 (87.37)	**0.036****
No	6 (6.59)	30 (15.46)	36 (12.63)	
Membership				
Yes	69 (75.82)	66 (34.02)	135 (47.37)	**0.000*****
No	22 (24.18)	128 (65.98)	150 (52.63)	
Training				
Yes	70 (76.92)	55 (28.35)	125 (43.86)	**0.000*****
No	21 (23.08)	139 (71.65)	160 (56.14)	
Income source				
Farming only	40 (20.62)	20 (21.98)	60 (21.05)	0.793
Farming + Non-farming	154 (79.38)	71 (78.02)	225 (78.95)	
VDC				
Phoolbari	61 (67.03)	80 (41.24)	141 (49.47)	**0.000*****
Others	30 (32.97)	114 (58.76)	144 (50.53)	
Credit				
Yes	9 (9.89)	18 (9.28)	27 (9.47)	0.869
No	82 (90.11)	176 (90.72)	258 (90.53)	
Final price				
Yes	22 (24.18)	44 (22.68)	66 (23.16)	0.780
No	69 (75.82)	150 (77.32)	219 (76.84)	
Selling crops in market				
Yes	70 (76.92)	155 (79.90)	225 (78.95)	0.566
No	21 (23.08)	39 (20.10)	60 (21.05)	

Source: Field survey (2013)
Note: Figure in parenthesis indicate column percentage;
*** 1% and ** at 5% level of significance

On average farmers have 0.5 ha of operational farmland which means most of the farmers in study areas are smallholders. Some 21% of the households relied solely on farming for their livelihood while 79% have non-farm income as well from sources such as service, business, rent, remittance, pension and wage laboring. Therefore, it can be implied that most of the households have other sources of income besides farming. Income from farming includes the monetary and non-monetary value of the total production for the last one-year from farming of cereals, vegetables, spices, pulses, oil seeds, fruits, livestock products and byproducts, and occasional income generated from selling trees as well. The income is calculated in Nepalese Rupees, a monetary unit of Nepal (US$1 = NRs. 98.56 (Source: Nepal Rastra Bank, March 31, 2013)). On average households have income worth NRs.193,989. Compared to farm income, households have higher non-farm income which stands at NRs.202,108 on average.

Around 50% of the respondents are from Phoolbari VDC. There is a significant difference in the number of respondents belonging to two groups of farming methods. Phoolbari VDC has higher number of organic farmers while other VDCs (Shivanagar and Mangalpur) combined have higher number of conventional farmer respondents. Agrovets are an exclusive store for agriculture related products where products for agricultural inputs (seeds, fertilizers, pesticides, etc.) and equipment, and livestock such as veterinary medicine could be found. This study takes distance to agrovet and market to understand the impact of these facilities. The average distance to nearest agrovet and market is 1.73 km and 2.84 km, respectively. Only 10% of the respondents have taken credit for the purpose of farming. Respondents used credit for investing in commercial crops, livestock rearing and/or for irrigation purpose. The average commercialization rate is 0.71, which is calculated as a ratio of total quantity of crops sold to total produced.

Table 4.2 Descriptive analysis of (continuous) variables across two different farming methods

Variables (Measurement)	Farming method						Total Mean± SD	T-test (P-value)
	Organic (n=91)			Conventional (n=194)				
	Min.	Max.	Mean± SD	Min.	Max.	Mean± SD		
Discrete								
HHHage of HHH	30	72	48.23± 9.81	26	84	50.30± 12.26	49.64± 11.56	0.159
HHHedu	0	17	7.37± 5.58	0	17	6.43± 5.37	6.73± 5.45	0.177
org_exp	1	55	**10.17± 10.25**	-	-	**-**	3.25± 7.48	**0.000 *****
org_training	0	12	**2.60± 2.66**	0	8	**0.56± 1.17**	1.21± 2.02	**0.000 *****
Continuous								
LFU	1.5	10	4.28± 1.84	1	11	4.29± 1.85	4.28± 1.84	0.961
LSU	0	12.7	2.12± 1.67	0	13.7	1.85± 1.75	1.94± 1.72	0.219
farm_size	.02	2.37	0.49± 0.39	.01	2.7	0.51± 0.41	0.50± 0.40	0.633
farm_income	1820	1014245	186717 ± 170360	2850	994692	197400± 186134	193989± 181016	0.643
non-farm income	0	960000	221715 ±220117	0	1080000	192911± 190825	202108± 200702	0.259
agrovet	.01	9	1.58± 1.34	.01	15	1.79± 1.89	1.73± 1.73	0.323
market	.04	15	3.07± 3.63	.01	15	2.73± 3.30	2.84± 3.40	0.426
commercialization	0	4.76	0.66± 0.75	0	3.99	0.74± 0.66	0.71± 0.69	0.371
cash_income	0	226648	**48999± 54685**	0	234669	**64359± 59887**	59455± 58621	**0.039 ****
SHDI	2.05	3.88	3.15± 0.38	1.72	3.81	3.11± 0.38	3.12± 0.38	0.349

Source: Field survey (2013)

Note: *** at 1%, ** at 5% and * at 10% level of significance

Approximately 23% of the respondents know the final price at which the consumer buys their product. The rest 77% sell their products to middlemen at a farm gate price. Roughly 79% of the respondents sell crops in the market and the remaining 21% use their farm production only for own household consumption. The gross farm cash income (income generated as a result of selling crops in the market without deducting the cost of production) is NRs.59,455 on average. It is significantly different among two farming methods, with conventional farm having higher gross farm cash income compared to organic farm. Finally the Shannon diversity index (SHDI), which is one of the indicators of crop diversity (Zhang, et al., 2012), is calculated by taking into consideration all the crops produced by the household under six categories of cereals, vegetables, spices, pulses, oil seeds and fruits (Appendix II). Households have SHDI value of 3.12 on average.

Chapter 5. Livelihood assets impacting adoption of a farming method

5.1 Introduction

Though organic farming is a growing phenomenon, its share in the global context still remains minimal. As of 2013, the global total share of organic to overall agricultural land including in-conversion areas remain only 0.98% and Nepal shares much smaller rate, which stands at 0.2% (FiBL & IFOAM, 2015). This suggests that organic farming does possess certain difficulties that hold farmers back from taking it on a larger scale. Thus, it is necessary to identify such factors for understanding the underlying issues which could contribute in policy implication or stimulate the necessary action by various stakeholders leading to the growth in the adoption rate of organic farming. With this objective, this study assesses factors that led some farmers to adopt organic while some to practice conventional farming method.

There has been a number of organic farming related studies conducted in the study areas. Adhikari (2009; 2011) finds that organic carrot and rice production system, respectively, results in higher benefit cost ratio. Study by Bhat and Ghimire (2008) has focused on controlling major diseases and enhancing production of organic vegetables, implying the scope of using bio-pesticides. Another study by Organiconepal (2006) focuses on making successful marketing method of organic farming goods and the importance of farmers' cooperative. Only Kafle (2011a; 2011b) has captured the issue of socioeconomic variables differing among adopters and non-adopters of organic farming in Phoolbari VDC. In any adoption studies of agricultural innovations, socioeconomic variables or livelihood assets are considered as important as agro-ecological variables and farmers' perception (Kafle, 2010). This study incorporates additional variables from what were used in the previous study and expands the territorial horizon by including two more adjoining VDCs to do inclusive analysis of factors impacting the adoption of organic farming.

5.2 Methodology

5.2.1 Variables selection

Farmers' livelihood assets have a major role to play in farm-related decision making and therefore its implication on adoption of organic farming is also discussed in various studies. More so, organic farming adoption in relation to livelihood assets or socioeconomic variables is highly context-specific. Among others are HHH's age and education; the relation of which resulting in adoption of organic practice varied according to different studies. For instance, Adesope et al. (2011) assumes that those who have been farming for a very long time are usually old, less educated and thus are more reluctant to change to organic farming. Contrastingly another study shows that older farmers with larger farms, for better-privileged relationship with extension services, are more likely to adopt organic method. They also tend to be more experienced in farming and are better educated (Alexopoulosa, Koutsouris, & Tzouramani, 2010). Thus, it is also expected that with higher experience, farmers are expected to improve their expertise in organic farming. Again Khaledi et al. (2011) suggested that educated and younger farmers allocate lesser share of their cultivated area to organic practice and those with older age allocate higher share. This study also takes primary occupation of HHH as one of the indicators resulting in adoption of organic farming because it is believed that a farming decision may vary with the extent of its contribution to one's livelihood. It is assumed that farming as primary occupation is expected to have positive impact on adoption as farmers would be concerned about practicing it in a more sustainable way for a long-term benefit. Those who are renting the farmland is expected to have negative impact on adoption of organic farming because they would be least concerned about conserving its soil fertility for long-term sustainability.

Khaledi et al. (2011) also opined that increase in farm area would result in higher chances of not following complete adoption of organic practice because of higher labor demand. It furthermore limits the complete adoption of organic practice when farmer's wage increases. Another reason could be economies of scale that can be achieved more effectively in larger conventional farms than smaller ones and therefore for financial gain farmers are less likely to consider a switch to organic farming. Again contrastingly Kafle (2011b) found farmers with large farm size to be better adopters than small farmers, probably because it signifies being resource-rich and thus suggested that organic production first be promoted to the large-scale farmers followed by small-scale farmers. But labor is probably one of the major defining factors among others as organic farming is labor intensive and family members have been the major source of labor in all agricultural methods irrespective of the fact that there has been increasing role of hired labor in farm practices (Pattanapant & Shivakoti, 2009). Like labor, livestock holding is also an important component of organic farming as it relies mainly on manure for soil fertilization. Thus, higher livestock holding is expected to result in higher propensity to adopt organic farming.

Non-farm income and social network relating to the adoption of organic farming could also be observed in various literatures. Since organic farming is usually riskier in terms of production loss during initial years of conversion (Halberg, Alroe, Knudsen, & Kristensen, 2006), farmers with no source of income other than farming that otherwise might have worked as a safety net, could feel hesitant to convert as they tend to be more risk averse. Social network is another important component that leads to participation in community activities which could provide benefit to farmers, specifically in the form of labor exchange, information sharing and knowledge gain on production, marketing, and even possibility of getting funds (Pattanapant & Shivakoti, 2009; Sarker, Itohara, & Hoque, 2009). Such activities could also in turn make farmers participate in training and can impact to what extent farmers adopt organic practice (Kafle, 2011b). Based on field observation, group formation in Phoolbari VDC is the oldest and has conducted more training and thus is expected to have more organic farmers compared to the other two VDCs (Appendix I). Besides, there might be other unobserved factors resulting in higher adoption of organic farming among VDCs.

Like training, access to relevant institutions like agrovets and market are expected to provide farming related information and access to pre and post-production services, although its impact on adoption of organic farming could be positive or negative. For example, agrovets offer both chemical fertilizers and pesticides as well as packaged organic fertilizers and bio-pesticides. It depends on farmers the kind of service they desire or get influenced by as a result of easy access to it. Likewise, if there is premium market for organic products, farmers would be encouraged to practice organic farming if they are closer to the market but in the absence of it, the case would be otherwise. Female-headed households are expected to have higher adoption rate of organic farming because they are presumed to be more health-conscious for their family members. Credit is expected to have positive impact as it can provide with necessary financial accessibility for the adoption of organic farming.

Table 5.1 Hypothesized relation of explanatory variables to practicing organic farming

Variables	Expected sign	References
HHHgender	-ve	
HHHage	+ve/-ve	Adesope et al. (2011); Alexopoulosa, Koutsouris, & Tzouramani (2010); Khaledi et al. (2011)
HHHedu	+ve/-ve	Adesope et al. (2011); Alexopoulosa, Koutsouris, & Tzouramani (2010); Khaledi et al. (2011)
HHHprimary_occu	+ve	Own assumption
rent	-ve	Own assumption
org_exp	+ve	Alexopoulosa, Koutsouris, & Tzouramani (2010)
LFU	+ve	Pattanapant & Shivakoti (2009)
LSU	+ve	Own assumption
farm_size	+ve/-ve	Alexopoulosa, Koutsouris, & Tzouramani (2010); Khaledi et al. (2011); Kafle (2011b)
ln_nonfarm_income	+ve	Halberg, Alroe, Knudsen, & Kristensen, (2006)
membership	+ve	Pattanapant & Shivakoti (2009); (Sarker, Itohara, & Hoque (2009)
org_training	+ve	Kafle (2011b)
VDC	+ve	Own assumption
agrovet	+ve/-ve	Own assumption
market	+ve/-ve	Own assumption
credit	+ve	Own assumption
final_price	+ve/-ve	Own assumption
commercialization	+ve	Own assumption

Market information such as knowing the final price of a product at which a consumer buys could either encourage or discourage organic farming. Farmers would be encouraged to adopt organic farming if they know that consumers pay higher price for organic products and vice-versa. One of the reasons farmer practice conventional farming is for higher profit. Thus, it is expected that higher the extent of commercialization, less will be the tendency to convert to organic farming.

Based on the above description, the expected direction of each variable against dependent variables is presented in Table 5.1.

5.2.2 Empirical model

The collected data is analyzed using bivariate probit model (BPM). Since our study uses two different farming categories: organic farming and conventional farming, this model is applicable to assess to what extent farmers adopting each of these farming method differ in terms of their socioeconomic characteristics or livelihood assets.

The empirical specification for probit model can be given by:

$$y_i^* = \beta_0' + x_i\beta_i' + \varepsilon_i \tag{5.1}$$

$$y_i = \begin{cases} 1 & \text{if } y_i^* > 0 \\ 0 & \text{otherwise} \end{cases} \tag{5.2}$$

where i is number of observations, y* is the unobservable latent variable, y is binary variable of whether a household is adopting organic farming or not, x is explanatory variables, β_0' is coefficient of intercept, β' is parameter to be estimated and ε is the normally distributed error term. This model however only gives the direction but not the actual magnitude of change of probability of independent variables' effect on dependent variable. This is why the study calculates marginal effect to measure to what extent the amount of change in dependent variable will be produced by a unit change in explanatory variables (Ayuya, Kenneth, & Eric, 2012). Marginal effect for probit model is given by:

$$\frac{\partial P}{\partial x_i} = \varphi\,(x_i\beta)\beta \qquad (5.3)$$

where ∂P is a partial derivative of probability that $y_i = 1$ with respect to x_i and φ is a distribution function for standard normal random variable.

The empirical specification for the model can be given by:

$$y^* = \beta_0 + \beta_1 ageHHH + \beta_2 HHHprimary\_occu + \beta_3 LSU + \beta_4 ln\_nonfarm\_income + \beta_5 membership + \beta_6 org\_training + \beta_7 VDC + \beta_8 agrovet + \beta_9 market + \beta_{10} commercialization + \varepsilon \qquad (5.4)$$

where ln is natural log.

As per the regression rule, diagnostic tests were carried out to check the problem of multicollinearity and heteroskedasticity in the data. Though according to Pindyck and Rubinfeld (1981), Variation inflation factor (VIF) is better than correlation matrix that fails to yield conclusive results, this study carries out both VIF and correlation matrix to check more vigorously the multicollinearity between any two variables. The VIF indicates whether a predictor has a strong linear relationship with the other predictor(s). It gave a value of 1.55, which is below 10 (Appendix III). According to Myers (1990), as cited in Field (2000), VIF value less than 10 indicates multicollinearity among the variables does not exist. Similarly, Field (2000) also asserted that if any two variables have correlation value above 0.80 or 0.90, it means that they correlate very highly. Again in our case, no combination of two variables showed value of more than 0.80, thus assisting us to conclude that there is no problem of multicollinearity in our data. Likewise, Breusch-Pagan/Cook-Weisberg showed significant P-value thus rejecting null hypothesis of homoscedasticity. It means that there are linear forms of heteroskedasticity. White's test did not show significant P-value implying that there is no problem of non-linear forms of heteroskedasticity, i.e., the variance of the error term is constant. To correct heteroskedasticity of any kind, following Nhemachena and Hassan (2007), model estimation was conducted using robust standard errors. Using robust standard errors, it neither changes the significance of the model nor the coefficients, but gives relatively accurate P values and is an effective way of dealing with heteroskedasticity (Wooldridge, 2006).

5.3 Result and discussion

5.3.1 Result from bivariate probit model and marginal effect

The probability of the model chi-square (72.25) is highly significant at 1% that supports the existence of a relationship between independent and dependent variables. The Pseudo R^2 suggests that 25% of the total variation in the values of dependent variable is explained by the independent variables in this regression equation (Table 5.2).

In case of HHH's age, the result deviates from the findings by Khaledi et al. (2011) and Alexopoulosa, Koutsouris, & Tzouramani (2010) but adheres to Adesope et al. (2011) which showed negative relation of farmer's age with practicing organic farming. The findings suggest that a year increase in age of HHH has a highly significant negative impact on the probability of practicing organic farming by 0.5%. It could be because with age, one's capacity to supply labor diminishes which is very much required in the case of organic farming. As benefit from organic farming materializes only after few years of conversion, it could also be that older farmers are less willing to try new technologies because of their diminishing enthusiasm given that they will be retired soon in the near future, thus leaving less time to enjoy the benefit. There is a 5% higher probability of adopting organic farming if the primary occupation of HHH is farming because they will be more concerned about farming sustainably for supporting their livelihood.

With higher livestock holding, which is among the fundamental components of organic farming as a source of manure for soil fertilizer, farmers' likelihood to take up organic farming goes up. A unit increase in LSU increases such likelihood by 3%. An increase of non-farm income by a percent also increases the chances of adopting organic farming by 1% because it will act as a safety net especially during the time of conversion when there is a risk of production failure. Membership in a group formed for the purpose of organic farming also increases the prospect of adopting organic farming by 11%. Being a member of such a group, farmers are provided with various learning platforms. Besides training, there is a high potential of knowledge generation and information gathering as a result of an interaction among various stakeholders. These members meet on a monthly basis to update with their saving and loan activities. Moreover, they also gather on numerous other occasions that are irregular in nature such as meeting with NGOs, government officials, organic certifying inspector or other stakeholders; for study trips; and while collectively selling organic products through a cooperative. But membership does not alone effect farmers' decision to convert as not all farmers are practicing organic farming or are engaged in related activities with the similar keenness (Explained more elaborately in Section 5.3.2). That is why training plays a major role in adoption of organic farming.

Table 5.2 Result from bivariate probit model and marginal effect for organic farming method

Variables	Probit model		Marginal effect
	Coefficient	P-value	
HHHage	**-0.01**	**0.087***	**-0.005**
HHHprimary_occu	0.16	0.446	0.05
LSU	**0.09**	**0.094***	**0.03**
ln_nonfarm_income	0.03	0.161	0.01
membership	0.33	0.143	0.11
org_training	**0.31**	**0.000*****	**0.11**
VDC	**0.56**	**0.005*****	**0.19**
agrovet	**-0.11**	**0.086***	**-0.04**
market	0.02	0.598	0.01
commercialization	-0.18	0.254	-0.06
constant	-0.96	0.041	

Note: *** 1% and * at 10% level of significance
Wald $\chi 2$ (10) = 72.25
Log pseudo likelihood = -133.84074

Number of observations = 285
Prob > $\chi 2$ = 0.0000***
Pseudo R^2 = 0.2502

Taking one more training will increase the probability of organic farming by 11%, which is highly significant as well. Training is provided by academicians, non-governmental and government organizations. One of the regular trainings conducted is FFS in which the group usually meets on a weekly basis where they learn-by-doing by assessing one crop at a time from as early as its plantation period till the time of harvest. Farmers usually divide groups to be in charge of growing a certain crop through various organic means such as Farm Yard Manure (FYM), bio-pesticides, vermicompost, mulching and so on. They discuss about the amount of inputs required, problems related to pests and diseases and its management and finally the amount harvested. Such learning process can take up to 16 weeks for each crop. Through such activity, farmers then try to replicate the most successful method in practice as well.

Table 5.3 Differentiating factors across VDCs

Variables	VDC (Mean±SD)			T-test
	Phoolbari	**Others**	**Total (n=285)**	
HHHage	50.55±11.96	49.32±11.74	49.97±11.85	0.440
HHHedu	7.38±5.53	6.44±5.48	6.94±5.52	0.201
org_exp	**5.06±8.95**	**1.5±5.82**	**3.38±7.83**	**0.001*****
org_training	**1.62±2.23**	**0.73±1.73**	**1.2±2.05**	**0.001*****
LFU	4.11±1.78	4.44±1.84	4.26±1.81	0.174
LSU	2.12±1.93	1.80±1.48	1.97±1.73	0.163
farm_size	0.58±0.46	0.51±0.38	0.55±0.42	0.167
farm_income	12.00±0.84	11.94±0.74	11.97±0.79	0.552
non-farm income	8.98±5.41	9.38±5.06	9.17± 5.24	0.565
agrovet	**2.12±1.66**	**1.47±1.84**	**1.81±1.77**	**0.006*****
market	**3.57±3.31**	**2.38±3.45**	**3.01±3.42**	**0.009*****
commercialization	0.94±0.73	0.86±0.57	0.90±0.66	0.159
SHDI	**3.26±0.31**	**3.02±0.41**	**3.15±0.38**	**0.000*****

Source: Field survey (2013)
Note: *** at 1%, ** at 5% and * at 10% level of significance

Phoobari VDC has the probability of having higher number of organic farmers by 19%. The group in Phoolbari VDC was established before the groups in other two VDCs and accordingly they have received more training related to organic farming (Table 5.3). Thus, it can also be suggested that the number of years these groups have been into existence and how vibrant they are into learning through programs such as FFS also has positive impact on possibility of more farmers practicing organic farming. Besides that, the distance to agrovet and market is higher for Phoolbari VDC and it also has higher SHDI than in other two VDCs. In addition to these, there might be other unobserved characteristics of Phoolbari VDC that resulted in more farmers adopting organic farming.

One more kilometer farther distance to agrovet decreases the probability of practicing organic farming by 4%. Agrovets, in addition to offering chemical fertilizers and pesticides are also selling commercially available packaged bio-fertilizers and bio-pesticides. Thus, uneasy access to such inputs might have discouraged farmers to take up organic farming. One more kilometer longer distance to market increases the probability of practicing organic farming by 1%. Organic farming boasts higher diversity which could be relied on for self-consumption and avoid buying or selling in the market which involves transaction costs. Higher the commercialization rate less will be the likelihood of practicing organic farming. Commercialization is mostly market oriented, which means that market oriented farmers are less likely to practice organic farming. A unit increase in commercialization rate will decrease the probability of practicing organic farming by 6%.

5.3.2 Nature of group formation

Since group membership alone does not indicate farmers' adoption of organic farming, this section examines the reasons for it. Table 5.4 provides the information on status of farming practice of group members after the formation of the group and reasons for practicing it. More so, it indicates how successful such groups have been in changing their members' farming behavior more towards organic farming since its inception.

Table 5.4 Farming practice after group formation

Farming status of member farmers after group formation	**Member farmers**		**Total (n=140)**
	Organic (n=71)	**Conventional (n=69)**	
Changed to organic farming through group	52 (73.24)	-	52 (37.14)
Same as before	19 (26.76)	26 (37.68)	45 (32.14)
Later changed to conventional farming	-	19 (27.54)	19 (13.57)
Organic farming area ≥ 0.0676 ha*	-	24 (34.78)	24 (17.14)

Source: Field survey (2013, 2014)
Note: Figure in parenthesis indicate column percentage
*** 1% level of significance
* Minimum land area to be group member

Some 73% of the member farmers practicing organic farming said they switched to organic farming after being a member of a group formed for the purpose of organic farming. They implied that they have become more health conscious through various interactions that occurred as a result of being a member. About 27% of the member farmers said they have been practicing organic farming even before the group came into existence. It means that these particular group of farmers have been following the traditional ways of farming, which their forefathers had practiced. These farmers are health conscious too but this method of farming is what they are used to and never felt like needing chemical inputs for various reasons. Therefore, the primary reason for practicing organic farming undeniably remains health rather than for monetary benefit from the premium market. Only one farmer claimed that he faced declining soil fertility overtime instead of increase in use of agro-chemicals. Farmers have become health conscious and as a result some also tend to grow same crop organically for home consumption and conventionally to sell in the market. Although some organic farmers confessed that they were compelled to use chemicals for cereals few years ago. When there is a pest and disease problem, they can let go of other minor crops, as it is grown in a small amount. But for cereal crops, which are grown on large scale and constitute larger portion of food consumption, it is riskier for farmers if in case they are not able to harvest the crops. Another challenge is organic seeds need to be dried hence increasing the cost, whereas in conventional method, use of pesticide is enough. The path to organic farming was also gradual for some farmers, meaning that they decreased the use of chemicals gradually so as not to face sudden loss.

Similarly, around 38% of the member farmers said that they never changed to organic farming after becoming a member and continued using chemical inputs like before. Some farmers opined that they tried cultivating organically but whenever there is pests attack or disease in crops, they could not help but use chemical pesticides in the fear of losing their crops, thus not being able to follow organic practice even for one whole year. Contrastingly there are nearly 28% of member farmers who tried organic farming for a short period such as for a season, or few months or a year. However they returned back to using chemical inputs entailing that organic farming requires more effort in terms of preparing and applying more amount of FYM, weeding and so forth. Most importantly, they too suggested that organic means of pests and disease management takes longer time and often times they face the risk of losing their crops. In addition to that, having to increase production for a particular season also remains their top most priority rather than sustainability in a long run.

From the field survey, it was also realized that having access to organically feasible crop varieties also indicates the possibility of practicing organic farming. Farmers claimed that crops like potato, tomato and kidney bean are difficult to produce organically because of fungus so research in collaboration with DADO is ongoing experimenting the mixture of Tricoderma and Cedominas (a process known as *Jaibik Bisadi* in Nepalese) in compost. In other vegetables like spinach, cowpea and mustard greens, and oil crop such as mustard, chemical pesticides are used. Off-season vegetables are difficult to grow organically and are usually possible only with the application of chemical inputs. In cereal crops such as rice, maize, wheat and oat; use of inputs like urea, Diamonium Phosphate (DAP) and Muriate of potash (MOP) is very common. In rice too, some varieties (like *Sabitri* rice) do not need urea but since all the farmers cannot have access to the seed of such varieties, they are compelled to grow those varieties that demand some amount of chemicals.

Finally approximately 35% of the member farmers have been practicing organic farming in less than or equal to 0.07 ha of land which is the minimum land area required to be under organic management to be a member of such group. Among these, some farmers started out with more area but later reduced it to this minimum size. Thus, there are member farmers who are practicing conventional farming and who are strictly following organic farming on less than or equal to the minimum required land area needed for being a group member. This shows easing of rules or not taking any firm precaution against such members.

It was found that there are farmers who want to remain a member and be a part of such group and those who no longer desires to be associated with such group anymore. Being a group member has its own pros and cons. In addition to being more health conscious and getting training on various facets of organic farming, they occasionally are entitled to receive various partial or full assistances such as seeds, bio pesticides container, water pump, compost-shed, push-cart, tractor, certification, etc. But on the other hand, there are various strains among members both within and across such groups as a result of unequal distribution of assistances, unequal participation in various group activities, less saving interest rate and unequal advantage of premium market. For instance, all three VDCs received 20 water pumps (motor) for irrigation, which is about a size of 2 inch and 20 bio-pesticides containers/sprayers. These are very limited given the huge number of members. It is thus prioritized based on those active members who regularly participate in group activities. In Mangalpur and Shivanagar VDC, they received 1 set of water pumps for each group (4 sets in total) and the rest was distributed to farmers in Phoolbari VDC. The providers justify that they allocate such things based on the number of members in a particular group in each VDC. The cooperative in Phoolbari VDC have also received NRs. 20,000 worth of cart to collect the farm produces and sell. In 2014, they also received assistance of 50% of the cost of tractor and the rest was paid by the members and NRs. 400,000 through Organic Certification Nepal (OCN) as a half of the cost required for certification and rest was paid by members/group itself.

In Mangalpur VDC, FFS was conducted for bitter gourd, cauliflower, broccoli and cabbage; participating in which farmers received seeds of cauliflower, pumpkin and lady's finger. Once organic seed exchange program was also held so that farmers can have access to organic seeds of different crops. This shows that member farmers in Phoobari VDC have received more assistance. Cooperation among members gets more difficult with increasing number of members. Because of this, since 2015, Shivanagar VDC formed two informal groups from the previous one; namely, Nawa Kiran Prangarik Krisak Samuha which has 30 members (4 males); and Jan Kalyan Prangarik Krishak Samuha which has 30 members (10 males). The low number of males in all the groups is because males are usually employed in non-farm sector, they have to travel more often than their female counterparts and as a result are less interested in meetings and other activities that a group member should take part in.

The cooperative in Phoolbari VDC is a collection point where produces from its member farmers are brought so as to send collectively to other cities where premium market exists. Farmers are able to get premium ranging from 9-140% but again it is not equally accessible to all its members. A farmer in Shivanagar VDC complained that there is no vehicle to transport produces to Phoolbari VDC, sometimes they are not informed and at times when they are, it is often too late and is in smaller quantities making it economically infeasible for them as transport cost is higher. Others too claimed that they are not made aware of such assistances when the actual distribution takes place and while collecting the produces for selling in the premium market in other cities. Those farmers who are responsible for such distribution claims that many farmers are not active when it comes to participating in various meetings. The only time they show up is once a month when it is time to pay for the monthly saving while some farmers choose to be absent even on such gathering and rather send their children on their behalf. Gathering for training or various meetings is an important time for farmers to strengthen their link. Thus, only those farmers who are regular are prioritized more while distributing such assistances as that too come in limited number. While marketing the crops in the premium market too, those excluded farmers claim that they do not get such information at all or only at the last minute. During such time, the demand is too less that farmers hesitate to take their products as price and time of transporting to the collection center is too high and troublesome. On the other hand, those farmers who are involved in marketing claim that they are not sure whether all the farmers are actually practicing organic farming or to what extent and on which crops. A farmer in Phoolbari VDC argued that the demanded variety and quantity of crop in the premium market itself is very limited, making it impossible or at least unrealistic to equally include all the farmers. The survey in 2015 found out that there are some shops that have opened to sell organic or environment-friendly products in *Chetrapur*, *Rampur*, *Sauraha*, *Bhandara* and *Bharatpur,* which are within a few kilometers distance but the farmers so far are not aware of it.

For a cooperative in Phoolbari VDC and in other groups too, there is a saving and credit facility for its members. The credit interest rate is just 1% (for non-member, the credit interest rate is 2%,) for loan, payable within 6 months and 0.7% for saving (eg., NRs. 1000 loan equals NRs.10 as interest payable and Rs.1000 saving equals NRs. 7 as interest receivable). Sometimes interest can be more than 1%, depending on required money to be paid as saving interest rate to its members. After three years, a member will get NRs. 6,521 each. In similar other formal sources providing saving and credit facilities, credit interest is 12% and saving interest is 8%. In Shivanagar VDC, interest rate is at 12% per year for both credit and saving. Thus, some farmers want to be non-member as they could save at the higher interest rate in other formal sources and they are not getting any benefit as such by being a group member. But doing so comes with deducting a certain amount of their initial fee as a penalty for terminating their membership and thus farmers hesitate to be non-member.

5.4 Conclusion

The study uses bivariate probit model to assess the factors influencing the decision of farmers adopting either organic or conventional farming method and marginal effect to analyze to what extent these factors can impact their decision. From this study it can be recommended that while introducing organic farming, households with higher livestock holding should be taken into account since livestock manure is the major input organic farmers rely on for soil fertilization. Consequently older farmers should not be prioritized for adoption of organic farming as their capacity to supply labor diminishes which is incompatible for this labor intensive farming method. Additionally, benefit from organic farming materializes only after few years of conversion, thus diminishing their enthusiasm, as they will be retired soon in the near future which leaves them with less time to enjoy the benefit.

Establishment of a group for the purpose of organic farming establishes a foundation for practicing organic farming in a group but it is the training that ultimately plays crucial role in knowledge generation and information dissemination and hence higher adoption rate among farmers over a longer period of time. Thus, forming such group could be an efficient tool to introduce organic farming on a larger scale. However, it comes with various other challenges of unequal member participation in group activities and unequal entitlement by each member to the benefit received in the form of various assistances and accessibility to the premium market. One of the ways to improve such situation could be to start selling in the specialized shops which have started to thrive very recently in the local area that can accommodate selling the produces from more farmers. Compared to other VDCs, farmers in Phoolbari VDC has higher probability of taking up organic farming because of group formation over a longer period of time, higher number of training and other unobserved characteristics. This study shows that farmers in other VDCs need more support and attention in their effort to practice organic farming. Agrovets also sell packaged organic fertilizers and bio-pesticides which could be the reason why farther distance to it results in lesser chances of practicing organic farming, indicating the importance of commercially available organic inputs for the vitality of organic farming.

Chapter 6. Nature of crop diversification

6.1 Introduction

Crop diversification means diversifying number of crops grown in a particular area at any given time. In other words, it is contrary to monocropping, which is growing a single crop. Crop diversification could be either horizontal diversification, which is adding or substituting crops into the current cropping method or vertical diversification that includes value addition activities that generally occurs in industrialization stage. This study considers horizontal diversification of crops that is commonly practiced by many countries in Asia-Pacific region (FAO, 2001). Crop diversification can provide numerous benefits on environmental, social and economic grounds. It is an indication of biodiversity as with diverse crops, number of habitats is also expected to increase. It leads to intercropping that delivers ecosystem services of improved pest control, resource use efficiency through facilitation and complementarity between species, nutrient cycling processes and product quality; and lowers level of weed infestation and nitrate leaching compared to single cropping.

One of the most common ways is intercropping cereals with legumes as latter is known to supply nutrients (maize + cowpea, maize + soybean, maize + pigeon pea, maize + ground nuts, maize + beans, sorghum + cowpea, millet + groundnuts, and rice + pulses). In study areas too, farmers were found intercropping for various reasons. For example, they intercropped crops needing more sunlight with less needing ones (wheat + rapeseed), crops needing more inputs with less needing ones (wheat + peas, corn + cowpea, chilli or soybean; cauliflower + coriander, radish, onion, carrot or garlic, potato + field beans), deep rooted with shallow rooted crops (pigeon pea + green gram), long duration with short duration crops (corn + soybean, carrot + radish) and for pests management (cauliflower + coriander, cabbage + garlic, tobacco + neem, spinach + onion, garlic or coriander).

Thus, crop diversification will help maintain production over time without degrading the environment. It improves resilience to withstand stress and other disturbances such as during incidences of single crop failure, environmental adversity or socio-economic shocks. Diversified farm can supply various combinations of nutrients consequently enriching households' diet and reduce household market dependency. In fact, it can develop market-orientation by producing high-value crops that generates additional income. It also improves employment opportunities by cultivating crops that has varying growing season all year round (Andersen, 2005; Scialabba, 2007; Johnston, Vaupel, Kegel, & Cadet, 1995; UNCTAD, 2003; Sipiläinen, Marklund, & Huhtala, 2008; Matusso, Mugwe, & Mucheru-Muna, 2012). This study assesses to what extent crop diversification differs among farmers characterized by individual socioeconomic background. It also aims to help understand how farmers' behavior in terms of crop diversification varies under particular farming method.

6.2 Methodology

6.2.1 Variables selection

Based on various literature reviews, Table 6.1 provides the expected direction of each of the variables used with respect to the crop diversity. Organic farm is known to have more diverse crops than conventional farm as diversity harmonizes with the basic principles of crop rotation or intercropping under organic farming that helps to function and manage farm through natural means (UNEP-UNCTAD, 2008; UNCTAD, 2003; Bengtsson, Ahnstrom, & Weibull, 2005). Since the basic intention of conventional farming is to reduce cost and increase production to maximize profit that could be achieved through crop specialization, it could be implied that crop diversity in this farming method tends to decrease with increasing intensity of specialization.

Measuring crop diversity is not only limited to farming method but studies have expanded its horizon to socioeconomic impact as well. Households' characteristics like age of decision makers resulted in increased diversity which could be related to their experience or their unwillingness to consider or accept modern variety that demands specialization. Education of household and labor availability is also expected to expand the variety choice (Gauchan, et al., 2005). Educated farmers become aware of various crops through better interaction and their ability to understand and utilize technical information associated with new crops also improves. They are also knowledgeable about nutritional value of various crops, which leads to crop diversification (Pandey S. , 2013; Benin, Smale, Gebremedhin, Pender, & Ehui, 2003; Rehima, Belay, Dawit, & Rashid, 2013). Labor availability will lead to increased diversity if there are less non-farm opportunities. Wealth-related variables like farm size, livestock holding, non-farm income and the like could also improve diversity richness because of their ability to take more risk (Gauchan, et al., 2005). Studies also show that resource-rich farmers with larger farm size are cultivating less varieties of crops through specialization as per the market demand or because it becomes difficult to manage multiple crops on larger area (Pandey S. , 2013; Rehima, Belay, Dawit, & Rashid, 2013). As for those with small farm size, crop diversity intensifies to meet household food requirement but a very small farm might not necessarily result in same way, as farmers will find it feasible to focus on other income sources.

Table 6.1 Expected relation of explanatory variables with respect to dependent variables

Variables	Expected sign	References
farm_method	+ve	UNEP-UNCTAD (2008); UNCTAD (2003); Bengtsson, Ahnstrom, & Weibull (2005)
HHHgender	-ve	Own elaboration
HHHage	+ve	Gauchan, et al. (2005)
HHHedu	+ve	Gauchan, et al. (2005); Pandey (2013); Benin, Smale, Gebremedhin, Pender, & Ehui (2003); Rehima, Belay, Dawit, & Rashid (2013)
HHHprimary_occu	+ve/-ve	Own elaboration
rent	+ve/-ve	Own elaboration
org_exp	+ve	Own elaboration
LFU	+ve	Gauchan, et al. (2005)
LSU	+ve/-ve	Gauchan, et al. (2005); Benin et al. (2003); Rehima et al. (2013)
farm_size	+ve/-ve	Gauchan, et al. (2005); Pandey (2013); Rehima, Belay, Dawit, & Rashid (2013)
ln_nonfarm_income	+ve	Gauchan, et al. (2005)
membership	+ve	Rehima, Belay, Dawit, & Rashid (2013)
org_training	+ve	Rehima, Belay, Dawit, & Rashid (2013)
VDC	+ve	Own elaboration
agrovet	+ve/-ve	Own elaboration
market	+ve	Gauchan, et al. (2005)
credit	-ve	Own elaboration

Studies by Benin et al. (2003) and Rehima et al. (2013) showed that livestock holding might actually work as a safety net against crop production failure and thus farmers with higher livestock might lead to greater specialization, which means lesser diversification. Distance from market is also expected to have positive and higher sales of particular variety has negative relation to diversity (Gauchan, et al., 2005). It is because with easier access to market, households will definitely take its advantage by specializing crops with higher market value and those with poor market access are more likely to rely on diversification to meet their consumption needs and to avoid transaction costs. In the same way extension services positively contribute to crop diversity, as it is associated with spread and adoption of new technologies that could be relevant to diversification (Rehima, Belay, Dawit, & Rashid, 2013). The group membership and training is expected to contribute positively in this regard as it concerns with organic farming. Thus, they are predicted to contribute positively or negatively on crop diversity.

It is expected that female-headed households will understand more about the benefit of having diversified crop as a requirement for household consumption as they are the ones who take charge of feeding their family. Farming as a primary occupation of HHH may or may not lead to higher diversification because on the one hand such farmer will think about fulfilling his family's requirement first, but on the other hand, he may be too competitive in earning higher income resulting in cultivating few crops with commercial value. Those farmers who have rented in the farmland in addition to farming in their own land could also have similar impact on crop diversification. Experience of practicing organic farming and Phoolbari VDC, which is more vibrant in performing activities related to organic farming, is also projected to have positive relation. This study also takes distance to nearest agrovet which might act as a medium of information and service provider that again could be inclined towards or deviate from organic farming. Because of having used credit for investing in commercial crops in addition to other purposes, it is expected to have negative relation to diversity.

6.2.2 Empirical model

The study calculates crop diversity using Shannon diversity index (SHDI). It is also commonly known as Shannon-Wiener/Weiner/Weaver Index. It captures both richness and evenness of species diversity. Richness implies the number of species cultivated whereas evenness refers to how evenly the cultivated area is distributed to various species. Species richness is the simplest way to measure the diversity but evenness captures a broader picture by taking relative abundance of species that enriches diversity. It is not necessary that species richness and evenness always have a positive relation. In many cases, diversity can be altered by changes in evenness without any change in species richness. Therefore, species richness and evenness should be assumed as two independent indices (Zhang, et al., 2012). Wilsey and Potvin (2000) found that species evenness has more linear relationship with total productivity than with species richness. By including these two variables can give better understanding of the status of diversity. SHDI has been used in different studies for assessing diversity of numerous kinds (Sipiläinen, Marklund, & Huhtala, 2008; Edesi, Malle, Adamson, Lauringson, & Kuht, 2012).

SHDI can be calculated with the following formula:

$$H = \sum_{i=1}^{n} (P_i * \ln P_i) \tag{6.1}$$

where H is SHDI, n is the number of cultivated crops, P is the share of area occupied by crop i from total cultivated area and ln is the natural logarithm. The value usually comes in negative in which case it should be converted to positive sign. When diversity index equals zero, it suggests that there is only one crop and hence no diversity. Thus, the value increases with the number of crops cultivated and when the area under which various crops cultivated becomes more evenly distributed. This study uses six different categories of crops with numerous types under each to calculate this index (Appendix II).

In order to assess impact of socioeconomic variables of farmers on crop diversity, Ordinary Least Squares (OLS) model has been used. It is the most frequently used model for fitting the regression line (Hoffmann, 2010). OLS model can be expressed as:

$$y_i = \beta_0 + x_i\beta_i + \varepsilon_i \qquad (6.2)$$

where y = SHDI, x = HH's socioeconomic characteristics, i = number of observations, β_0 = coefficient of intercept and β_i = parameter to be estimated, and ε = error term.

The empirical specification for the model can be given by:

$$\begin{aligned} SHDI &= \beta_0 + \beta_1 farm\_method + \beta_2 HHHedu + \beta_3 org\_exp + \beta_4 LFU + \beta_5 LSU + \\ &\beta_6 farm\_size + \beta_7 ln\_nonfarm\_income + \beta_8 membership + \beta_9 org\_training + \\ &\beta_{10} VDC + \beta_{11} agrovet + \beta_{12} market + \beta_{13} credit + \varepsilon \qquad (6.3) \end{aligned}$$

where ln is natural log.

As per the regression rule, diagnostic tests were carried out to check the problem of multicollinearity and heteroscedasticity in the data. The VIF gave a value of 1.42, which is below 10 (Appendix IV), indicating multicollinearity among the variables does not exist. Likewise, Breusch-Pagan/Cook-Weisberg gave significant P-value (0.0359) thus rejecting null hypothesis of homoscedasticity. It means that there are linear forms of heteroscedasticity. White's test did not show significant P-value (0.3818), implying that there is no problem of non-linear forms of heteroscedasticity, i.e., the variance of the error term is constant. To correct heteroscedasticity of any kind, model estimation was conducted using robust standard errors.

6.3 Results and discussion

6.3.1 Descriptive analysis

Figure 6.1 shows distribution of number of crop types under each category across the two farming methods. It is found that the number of crop types under all crop categories (cereals, vegetables, spices, pulses, oil seeds and fruits) is lesser in conventional farm compared to organic farm. Therefore it can be implied that the overall crop types or richness is higher in organic farm than conventional farm.

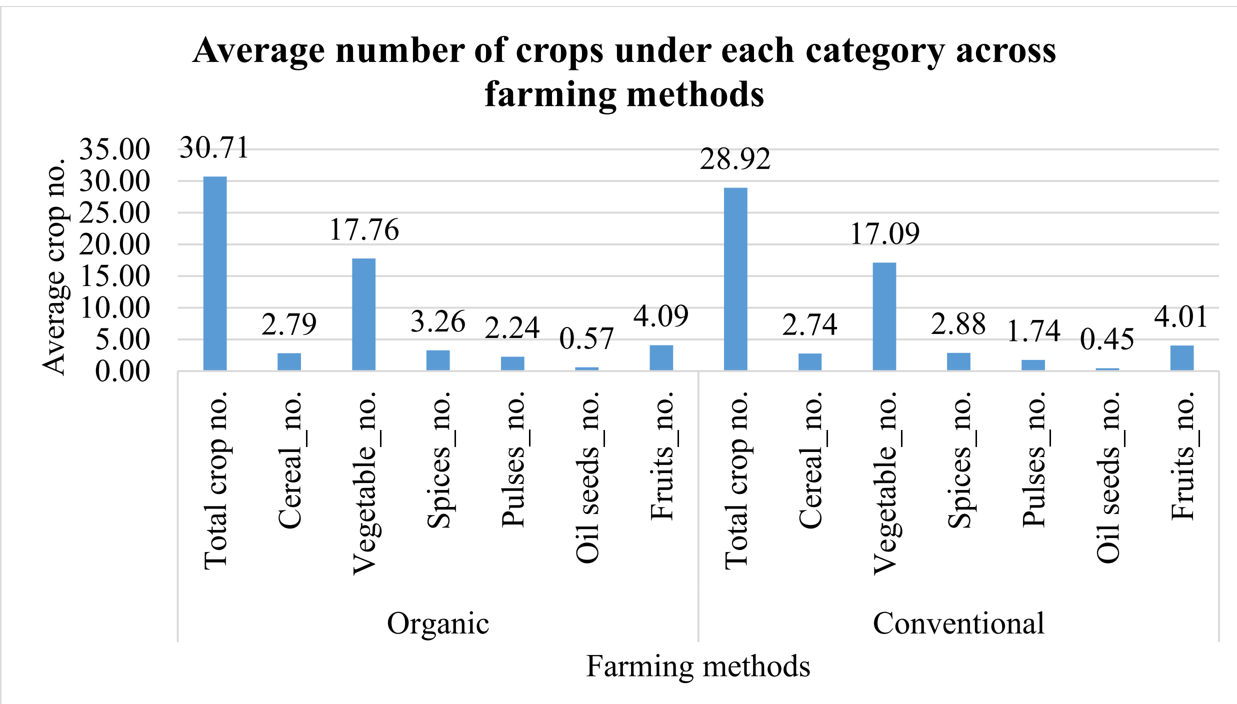

Figure 6.1 Distribution of crop types under various categories and across various farming method
Source: Field survey (2013)

Figure 6.2 shows average SHDI across the two farms, which suggests that organic farm has higher SHDI on average compared to conventional farm. The mathematical derivation of an ideal diversity index is less likely to be achievable as in reality various crops are required in various quantity to satisfy our daily needs; for example cereal crops vs. other crops. However, comparing with the maximum diversity index gives a much more achievable scenario. In this case the maximum diversity index is 3.88. Thus, on average organic farm can further improve SHDI by 0.73 and conventional farm by 0.77.

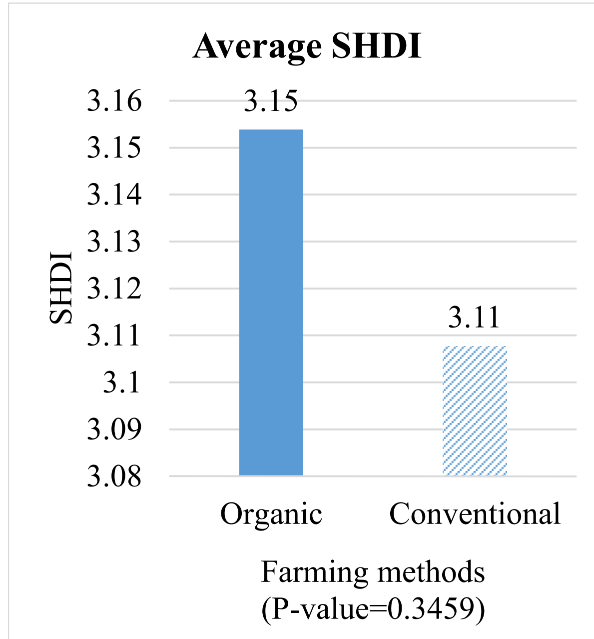

Figure 6.2 Average SHDI across farming method
Source: Field survey (2013)

6.3.2 Results from ordinary least square model

Table 6.2 provides result from OLS model for SHDI against various HH socioeconomic variables. The P-value for the regression model as a whole is highly significant at 1%, which supports the existence of relationship of independent variables with dependent variable. The R^2 value suggests that about 27% of the total variation in the value of dependent variable is explained by the independent variables in this regression equation. The result shows that organic farm has lower SHDI than conventional farm by 0.17, which is highly significant at 1%. It could be understood that unlike the traditional belief, organic farm might not necessarily be better in SHDI than conventional farm. Moreover, organic farm has higher number of crops (Figure 6.1) but lower

SHDI, which indicates that the crops cultivated are not as evenly distributed as in conventional farm.

Table 6.2 Result from OLS regression model for SHDI

Variables	Coefficient	P-value
farm_method	**-0.17**	**0.004*** **
HHHedu	**0.01**	**0.001*** **
org_exp	0.004	0.149
LFU	0.01	0.289
LSU	**0.03**	**0.007*** **
farm_size	-0.01	0.805
ln_nonfarm_income	**0.01**	**0.024** **
membership	**0.10**	**0.081* **
org_training	**0.04**	**0.002*** **
VDC	**0.17**	**0.000*** **
agrovet	0.01	0.275
market	**0.01**	**0.032** **
credit	-0.04	0.523
constant	2.65	0.000***

Note: *** 1%, ** 5% and * at 10% level of significance

Number of observations = 285 Prob > F = 0.0000***

F (13, 271) = 8.29 R-squared = 0.2710 Root MSE = 0.33573

Education of HHH tends to contribute more in crop diversity. A year increase in formal education will have index increase by 0.01, significant at 1% level. As referred in previous studies, educated farmers are better aware of various crops through interaction, have better comprehension of various crop types and probably are knowledgeable about nutritional value of such crops. A year increase in experience in organic farming increases SHDI by 0.004, suggesting that with such experience, farmers' realization of benefits of crop diversity also increases. A unit increase in LFU increases SHDI by 0.01, signifying higher diversity demands higher labor for managing diverse crops. A unit increase in LSU increases SHDI by 0.03, which is significant at 1%.

Livestock holding complements crop diversity as a way of traditional integrated farming which could be the reason these variables complement each other.

A hectare increase in farm size is negatively correlated with SHDI by 0.01, entailing that with bigger farm size it will be difficult to have diversified farm, which demands more labor and other resources. Thus, at some point, farmers intensify certain crops rather than keep adding other crop types due to difficulty in managing larger farms. Non-farm income is positively related to increasing SHDI at 5% significance. It suggests that as income from non-farm source increases by a percent, it will increase SHDI by 0.01. With non-farm income source, farmers would no longer have to be competent in crop specialization, the intention of which is to increase income. Thus, they would rather grow lesser amount but with more varieties to fulfill their own household need.

Membership in a group established for the purpose of organic farming and training provided through it has positive correlation to increasing SHDI by 0.10 and 0.04, significant at 10% and 1%, respectively. This implies that crop diversity is encouraged through the activities including training and interaction that takes place in these groups. It has been able to instill basic features of organic farming through higher SHDI. Farm in Phoolbari VDC is found to have higher SHDI by 0.17 on average than in other two VDCs, significant at 1%. A kilometer distance to agrovet will increase SHDI by 0.01, proposing that inconvenient access to various agro-inputs which are offered by agrovets, especially the chemical inputs encourages farmers to practice traditional way of farming rather than specializing in few crops. A kilometer distance to market will increase SHDI by 0.01, significant at 5%. As observed by Gauchan et al. (2005), easier access to market will encourage households to specialize in those crops, which have higher market value. Contrariwise, poor market access makes farmers more likely to diversify the crop to meet their own consumption needs and to avoid transaction costs required for buying or selling the crops. Finally credit has a negative impact on SHDI by 0.04, which means that among others, farmers' use of credit for commercial farming leads to decrease in SHDI.

6.4 Conclusion

Diversity richness and evenness are two separate entities, the latter being a more comprehensive way of measurement. Organic farm in the study areas is richer in integrating more number of crop types (richness) but is poor in evenness, which resulted in having lower SHDI than conventional farm. Since crop evenness is better indicator of improved productivity than crop richness, it can be implied that farmers should be made aware of this fact in order to improve their SHDI and hence the productivity. More so, organic farm should be focused more on this aspect. Overall, there is a room for upgrading diversity index in both farms which literatures indicate will lead to more balanced and enriched biodiversity, thus improving the environmental services.

The socioeconomic variables that have significant positive impact on SHDI are education attainment, livestock holding, non-farm income, group membership, training and belonging to Phoolbari VDC. Clearly, educated farmers have more knowledge on various crops and its benefits to health. Non-farm income allows farmers to intensify diversification for own household consumption rather than having to specialize for increasing income. Membership in a group formed for the purpose of organic farming and training related to organic farming can improve

SHDI because the purpose of such group formation and training is to make farmers aware of benefits of agro-ecological principles resulting in improvement of soil fertility and hence the production. Farm in Phoolbari VDC has better SHDI, which means that other VDCs should be focused more in improving the SHDI. Finally farther the distance to the market will encourage farmers to increase SHDI because they will prioritize on being self-sufficient and avoid buying or selling in the market to save the transportation cost. Easier access to market leading to low SHDI suggests that market is only favorable for few selected crops, which will encourage farmers for crop specialization. If there were such opportunities for variety of crops, then it would lead to diversifying crops, which also is beneficial for overall production through various environmental services. Therefore, any effort to improve SHDI should consider these characteristics. Most importantly the effort should also be made to cultivate crops more evenly in addition to having numerous types to reap more benefit from environmental point of view, ultimately resulting in higher production.

Chapter 7. Organic means of crop management practices

7.1 Introduction

Crop management practices in this chapter indicate organic means of soil and pest management practices. Soil is a principal component that influences farm productivity. It is the basis for plant growth by supplying nutrients, water and root support. It maintains biodiversity by providing habitat for billions of organisms. Soil fertility is a result of both inherent and dynamic soil properties. Inherent soil property is a result of natural soil forming processes whereas dynamic soil property is defined by how well it is managed by humans (Green & Brye, 2008). Therefore, adopting various management practices can impact on dynamic properties of soil. Soil management practices deserve greater attention for various reasons, one among which is the issue of food insecurity. It is one of the major challenges facing the world today and is more prevalent in developing countries where agriculture remains a major sector. Declining soil fertility to the large extent is responsible for lower productivity and hence better soil management practice could be one of the ways to combat this situation. The fact that there is continuous growth in demand for producing more on a limited area requires us to focus on management strategies that lead to better soil fertility for enhanced productivity (Green & Brye, 2008; Huili, Dan, Xiaojuan, & Feng, 2013; OECD, 2008). Nepal remains no exception and faces similar challenges of declining soil fertility along with the need to increase its food production for growing population. Declining soil fertility is a result of changes in agricultural practices through changes in technology and farmers' knowledge. Soil erosion, organic matter depletion, acidification, degradation of forest and marginal land, crop intensification, and insufficient and unbalanced use of chemical fertilizer are the major reasons for soil fertility depletion in Nepal (Bista, Ghimire, Shah, & Pande, 2010; Shrestha, Raes, & Sah, 2013).

Usually organic farmers are known for being better managers of soil. It relies on managing soil organic matter that enhances chemical, biological and physical properties of soil, thus optimizing the crop production. The difference between organic and conventional way of soil management is that former relies on longer-term solutions with the objective of preventing rather than reacting and the latter is based on short-term solutions (Watson, Atkinson, Gosling, Jackson, & Rayns, 2002). However, in developing countries even though there is an influx of modern inputs such as chemical fertilizers, farmers still incorporate traditional ways of soil management practices such as FYM (Bista, Ghimire, Shah, & Pande, 2010; Kabuli & Phiri, 2007). As for managing the pests, bio-pesticides are known to be the non-toxic alternative to the conventional means (EPA, 2013) which means that unlike chemical pesticides, bio-pesticides do not leave residue in food which is detrimental for our health. The previous study on bio-pesticides in the study areas only deals with its scope of usability but does not analyze its adoption rate which is much more important as it reveals the benefits or problems encountered in actually practicing it. Therefore, the main objective of this study is to assess how adoption of organic means of crop management practices (OCMPs) differs among organic and conventional farmers with various socioeconomic characteristics. Understanding the determinants of farmers' choices of OCMPs among the various available choices can provide insight on the factors that enable or constrain such actions and guide in developing farm-level adoption strategies.

7.2 Methodology

7.2.1 Variables selection

This study considers five organic means of crop management practices: mulching, compost-shed, bio-pesticides, bio-slurry and others (vermi compost and/or plastic cover). Mulching is a process of covering soil surface around the plants to conserve moisture content, protect plant roots, reduce weed growth and improve overall soil health and fertility. Farmers in our study area are practicing either crop or plastic mulch, which are then combined to form a variable ‘mulch’. It was found that farmers are either applying FYM or compost for soil management. Compost is a mix of organic material that includes manure, leaves and any other decomposable material. It supplies significant quantities of organic matter, improves soil structure and its water holding capacity. This study takes compost-shed as a proxy for quality compost or FYM because it preserves the compost/manure pile from volatilization by sun or leaching by rainfall and maintains its nutrient availability (Bista, Ghimire, Shah, & Pande, 2010). The survey found that farmers are either buying bio-pesticides from the market or are preparing by themselves. Bio-pesticides are meant for controlling pests through non-toxic means and thus have no harmful effect on soil unlike the conventional pesticides (EPA, 2013). Bio-slurry, on the other hand, is a byproduct obtained from biogas plant after the dung or other biomasses have been digested for the generation of gas. It also revitalizes soil fertility and this study takes biogas as a proxy for farmers applying bio-slurry. The variable ‘others’ include those using plastic cover and/or vermicompost. Plastic cover is the way of covering the plants with a plastic-clad semi-circular structure. It helps increase production and improve quality by managing soil moisture and subsequently making nutrients available (Montri

& Biernbaum, 2009) which means that farmers will not have to or rely less on conventional means that has detrimental impact on soil overtime. Vermicompost is yet another high-quality compost produced from worm castings. Since the number of respondents undertaking these (whether separately or combined) were very limited (only 6% of farmers did plastic cover and 7% used vermicompost), it has been combined to form the variable ‘others’.

Literatures were reviewed to learn how adoption of soil conservation or sustainable pest management technologies might differ among farmers with various socioeconomic variables. Most of the studies were conducted on adoption of Integrated Soil Fertility Management (ISFM), which comprises of mineral fertilizers, locally available soil amendments (such as lime and phosphate rock) and organic matter (crop residues, compost and green manure). ISFM emphasizes on locally acceptable practices leading to nutrient and water use efficiency, thus increasing the agricultural productivity (IFDC, 2014). The soil management practices incorporated in this study also aims to improve soil fertility for enhanced production. Hence, it could be assumed that the socioeconomic variables will have similar impact on adoption of organic means of pest management practices because it also relates with sustainable practices.

Studies show that different socioeconomic variables will have varying impact on adoption of new technologies. The age of HHH’s influence on a decision to adopt may be positive or negative. The older farmers might feel reluctant to change their old ways compared to younger ones who are more knowledgeable about new practices and who might want to take risk of trying out new technology because of their far sighted vision in farming. But on the other hand older farmers have more experience, resources and authority, which might induce them to adopt new technologies as well (Akinola & Owombo, 2012). Study by Mugwe et al. (2009) agrees with the former reasoning of impact of age on technology adoption. Studies basically relate age with experience of farmers and conceive to have similar impact on technology adoption. It is revealed that experienced farmers are less likely to adopt new technologies because less experienced ones, due to lack of knowledge, are more responsive toward new technologies and with experience, they realize that such technologies are not suitable for the local ecosystem (Kuntariningsih & Mariyono, 2013). In this case, bio-pesticides and vermicompost are comparatively new practices. Another reason could be that experienced farmers are more likely to retire in the near future which means that they will have less time to reap the benefit from such investment (Grazhdani, 2013). In this study we take experience as years of practicing organic farming. So we expect that it could have either positive or negative impact because with experience of organic farming, farmers are anticipated to be more competent in adopting organically viable practices but on the other hand, as shown by literatures, experienced farmers indicate age too and so they might not find it beneficial over a short time period that they have before they retire or they just realize the unfeasibility of such technology.

Education possesses ability to obtain, process, and use new information and therefore could have positive influence in the adoption of technologies that require technical knowledge (Akinola & Owombo, 2012; Grazhdani, 2013; Adolwa, Esilaba, Okoth, & Mulwa, 2010). Household size can also have both positive and negative influence on adoption of these technologies. It is usually taken as a proxy for labor. With more members there will be higher labor supply to adopt and practice new technologies. But more members also mean more pressure for consumption, meaning labor might have to be diverted for earning higher income. Thus, it is difficult to generalize how it will impact on adoption of these technologies (Akinola & Owombo, 2012). Although studies by

Kuntariningsih & Mariyono (2013) and Mugwe et al. (2009) agrees with the former assertion, showing that higher supply of labor is an indication of technology adoption because such technologies generally require more labor. Livestock holding is shown to have inverse relation to technologies such as mulching because in mixed farming method, livestock holding and crop mulching competes for crop residue (Jaleta, Kassie, & Shiferaw, 2012). But study by Mugwe et al. (2009) showed that less livestock holding implies less manure supply which is why farmers will be willing to look for other alternatives or will try to manage in a better way so as to maximize the effectiveness of small quantities of manure they have to improve soil fertility. Adolwa et al. (2010) suggests that livestock holding is an indication of resource endowment and are more likely to look for information on new agricultural technologies and subsequently practice it.

It is assumed that larger farm size also result in higher adoption rate because it signifies increased availability of capital, which makes investment in such technologies more feasible. It can also be implied that those with small farm size are usually risk averse and thus hesitate to invest in technologies with uncertain results in their limited farm (Akinola & Owombo, 2012; Grazhdani, 2013). In a study by Grazhdani (2013), farm income is a critical variable showing positive correlation with adoption of conservation-oriented farming. Technology being a normal good, it is perceived that farmers with an intention of amplifying the farm income will be more inclined into implementing these technologies. Non-farm income provides the much needed supply of capital, which makes adoption of these technologies feasible (Akinola & Owombo, 2012). Contrastingly, Adolwa et al. (2010) found non-farm income to negatively influence the adoption of soil management technologies, as people preferred investing such income in non-farm activities. Training is undoubtedly an important component, which encourages farmers to adopt these technologies. However it may not have any significant impact if farmers already are knowledgeable about the importance but lacks resource to purchase and implement such technologies (Bizimana, 2013).

Referring to reviewed literatures, Table 7.1 provides the hypothesized relation of various socioeconomic variables of farmers against the OCMPs, which they have adopted. As for the farming method, it is expected that organic farmers will adopt all of the practices incorporated in this study since they will be more conscious of improving soil fertility and managing pests through organic means. Conversely, conventional farmers are expected not to adopt any of these practices as it is assumed that they will prefer to rely on conventional means for such management. The male-headed households and if HHH's primary occupation remains farming, it is expected to have positive impact on adoption of these practices because of having competitive aim of increasing production. Those who have rented in the land in addition to farming in their own land is expected to have negative impact on such adoption because they will be constrained with resources to make an investment in such technologies. Group membership is expected to increase the adoption rate because the whole purpose of such group is to enhance organic farming. Farmers belonging to Phoolbari VDC are also expected to have higher adoption rate as activities related organic farming is more vibrant there compared to other two VDCs. Distance to agrovet and market could act as means of information on both organic and conventional technologies and provide accessibility to use them as well. Having access to credit is also expected to have positive impact as it enables farmers to make investments. Finally commercialization rate is anticipated to have negative impact on adoption as it mainly relies on conventional means for boosting production in short-run for higher profit.

Table 7.1 Expected sign of socioeconomic variables against dependent variables

Independent variables	Dependent variables (Expected sign)					References
	Mulch	Compost-shed	Bio-slurry	Bio-pesticides	Others	
farm_method	+ve	+ve	+ve	+ve	+ve	Own elaboration
HHHgender	+ve	+ve	+ve	+ve	+ve	Own elaboration
HHHage	+ve/-ve	+ve/-ve	+ve/-ve	+ve/-ve	+ve/-ve	Akinola & Owombo (2012); Kuntariningsih & Mariyono (2013); Grazhdani (2013)
HHHedu	+ve	+ve	+ve	+ve	+ve	Akinola & Owombo (2012); Grazhdani (2013); Adolwa, Esilaba, Okoth, & Mulwa (2010)
HHHprimary_occu	+ve	+ve	+ve	+ve	+ve	Own elaboration
rent	-ve	-ve	-ve	-ve	-ve	Own elaboration
org_exp	+ve/-ve	+ve/-ve	+ve/-ve	+ve/-ve	+ve/-ve	Kuntariningsih & Mariyono (2013); Grazhdani (2013)
LFU	+ve/-ve	+ve/-ve	+ve/-ve	+ve/-ve	+ve/-ve	Akinola & Owombo (2012); Kuntariningsih & Mariyono (2013); Mugwe et al. (2009)
LSU	-ve	+ve	+ve	+ve	+ve	Jaleta, Kassie, & Shiferaw (2012); Mugwe et al. (2009); Adolwa et al. (2010)
farm_size	+ve	+ve	+ve	+ve	+ve	Akinola & Owombo (2012); Grazhdani (2013)
ln_farm_income	+ve	+ve	+ve	+ve	+ve	Grazhdani (2013)
ln_nonfarm_income	+ve/-ve	+ve/-ve	+ve/-ve	+ve/-ve	+ve/-ve	Akinola & Owombo (2012); Adolwa et al. (2010)
membership	+ve	+ve	+ve	+ve	+ve	Own elaboration
org_training	+ve/-ve	+ve/-ve	+ve/-ve	+ve/-ve	+ve/-ve	Bizimana (2013)
VDC	+ve	+ve	+ve	+ve	+ve	Own elaboration
agrovet	+ve/-ve	+ve/-ve	+ve/-ve	+ve/-ve	+ve/-ve	Own elaboration
market	+ve/-ve	+ve/-ve	+ve/-ve	+ve/-ve	+ve/-ve	Own elaboration
credit	+ve	+ve	+ve	+ve	+ve	Own elaboration
commercialization	-ve	-ve	-ve	-ve	-ve	Own elaboration

7.2.2 Empirical model

Various studies have adopted different models to assess factors influencing one's decision to adopt a certain practice. However, each model has its limitations that makes them inappropriate to be used for studies with certain purposes. For example, Heckman sample selection probit model has been used to analyze the binomial choice of adopting conservation agriculture (Broeck, Grovas, Maertens, Deckers, Verhulst, & Govaerts, 2013), and perception and adaptation to climate change (Ndambiri, Ritho, & Mbogoh, 2013) with respect to farmers' socio-economic variables. However, this model does not differentiate between the several kinds of conservation practices, or perception and adaptation measures undertaken by the households. Different farming practices can be impacted by different socio-economic variables. Hence, to combine all the sub-components into one and to assume the impact of certain variable is similar throughout leads to biasness. When the information of variables leading to a certain practice is known, it is clearer to seek out appropriate action to encourage adoption of one practice over another.

Univariate probit model provides another alternative of doing so by modelling each of the farming practices individually as a function of the common set of explanatory variables. But it ignores unobserved and unmeasured common factors affecting the different management practices. In other words, this model is undesirable for reason of failing to see relation among various management practices. Adopting any practices could be complementary or competing to each other. In this case, a farmer might use bio-pesticide and complement it with mulching. Likewise, bio-slurry might compete with compost as both require animal manure as a primary input. Thus, overlooking potential correlations among these practices may lead to statistical biasness and inefficient estimates (Nhemachena & Hassan, 2007). Also since this study incorporates organic and conventional farmers, it would be interesting to see how these farmers differ in adopting such practices. Multinomial logit (MNL) model assumes independence of irrelevant alternatives (IIA) and that the practices be mutually exclusive which again in this case is not true. Farmer's decision to choose a certain practice might change when one or more additional alternatives are available. Similarly, a farmer can choose two or more practices simultaneously. The drawback of multinomial discrete choice model is it fails to interpret effect of independent variables on adopting each practices separately (Golob & Regan, 2002).

Considering the possibility of simultaneous adoption of soil management practices and the potential correlations among these practices as well as between unobserved disturbances, multivariate probit (MVP) model has been used in this study. Furthermore, it relaxes the assumption of IIA. The MVP model assumes that given a set of explanatory variables, the multivariate response is an indicator of the event that some unobserved latent variable that is assumed to arise from a multivariate normal (Gaussian) distribution falls within a certain interval (Tabet, 2007; Belderbosa, Carree, Diederen, Lokshin, & Veugelers, 2004). Referring to Tabet (2007), the MVP model in this study is characterized by a set of binary dependent variables Y_{ij}, where i is the independent observations and j available options of binary responses. Let Z_{ij} be a vector of latent variables so that:

$$Z_{ij} = \beta_0' + x_{ij}\,\beta + \varepsilon, \quad i = 1, \ldots, n \tag{7.1}$$

where x_{ij} represents vector of explanatory variables which can be discrete or continuous, β_0' is coefficient of intercept, β is a vector of unknown parameters to be estimated and ε is the error term distributed as multivariate normal distribution with zero mean and unitary variance.; $\varepsilon_i \sim N(0, \Sigma)$, where Σ is the variance–covariance matrix that has a value of 1 on the leading diagonal. The off-diagonal elements in the covariance matrix $\rho_{kj} = \rho_{jk}$ is the unobserved correlation between the stochastic component of the k^{th} and j^{th} options (Young, Valdez, & Kohn, 2009; Cappellari & Jenkins, 2003). The relationship between Z_{ij} and Y_{ij} can be provided as follows:

$$Y_{ij} = \begin{cases} 1 & \text{if } Z_{ij} > 0; \\ 0 & \text{otherwise} \end{cases} \quad j = 1, \ldots, J \tag{7.2}$$

By integrating over the latent variables Z, the likelihood of the observed discrete data can then be obtained by the following specification:

$$P\,(Y_{ij} = 1 \mid X_i, \beta, \Sigma) = \int A_{ij} \ldots \int A_{i1} \varnothing_T\,(Z_{ij} \mid X_{i,} \beta, \Sigma)\, dZ_{ij} \tag{7.3}$$

where A_{ij} is the interval $(0, \infty)$ if Y_{ij}=1 and the interval $(-\infty, 0]$ otherwise, and $\varnothing_T\,(Z_{ij} \mid X_{i,} \beta, \Sigma)\, dZ_{ij}$ is the probability density function of the standard normal distribution. To estimate the MVP model this study uses the simulated maximum likelihood (SML) using Geweke-Hajivassiliou-Keane (GHK) simulator, which is considered as the most popular method for evaluating multivariate normal distribution function in STATA developed by Cappellari & Jenkins (2003). According to Cappellari & Jenkins (2003), when number of draws and observations are infinite, the SML estimator is consistent. Simulation (finite sample) bias can be reduced to negligible levels when the number of draws is raised with the sample size. Generally for the large sample size (thousand and above) it is sufficient to have number of draws equal to the square root of the sample size. But for small sample size, the number of draws should be sufficiently large. Thus, for this study the number of draws (R) was set to 100 (from default of R=5) to ensure reliable estimates.

As per the regression rule, diagnostic tests were carried out. For each individual choice variables, OLS estimates were run against the same set of explanatory variables to conduct a diagnostic tests in order to check if there is any problem of multicollinearity and heteroscedasticity in the data. The VIF value for all the independent variables was much below 10, which means that there is no problem of multicollinearity among the variables (Appendix V). Likewise, Breusch-Pagan/Cook-Weisberg showed significant P-value for all individual choice variables, at varying level of significance, thus rejecting null hypothesis of homoscedasticity. It means that there are linear forms of heteroscedasticity. On the other hand, White's test did not show significant P-value for any of the individual choice variables, implying that there is no problem of non-linear forms of heteroscedasticity, i.e., the variance of the error term is constant. To correct heteroscedasticity of any kind, model estimation was conducted using robust standard errors.

The empirical model for the study is given by:

$$y_{n=5} = \beta_0 + \beta_1 \text{farm\_method} + \beta_2 \text{rent} + \beta_3 \text{org\_exp} + \beta_4 \text{LFU} + \beta_5 \text{LSU} + \beta_6 \text{farm\_size} + \beta_7 \text{ln\_farm\_income} + \beta_8 \text{ln\_nonfarm\_income} + \beta_9 \text{org\_training} + \beta_{10} \text{credit} + \beta_{11} \text{commercialization} + \varepsilon \quad (7.4)$$

where y = mulch, compost-shed, bio-slurry, bio-pesticide and/or others (plastic cover and/or vermicompost), and ln is natural log.

7.3 Results and discussion

7.3.1 Descriptive analysis

Figure 7.1 and 7.2 provides information on the extent of adoption of OCMPs and its distribution across the two different farming methods prevalent in the study areas. About 72% of the respondents did mulching, 23% has a compost-shed, 43% has biogas from which they get bio-slurry, 19% uses bio-pesticides and only 4% and 6% uses plastic cover and vermicompost, respectively. Among others, mulching is the most traditional form of soil fertility management practice considered for this study, which is why its adoption rate is higher than other practices. Mostly organic farmers compared to conventional farmers adopt all OCMPs considered in this study. Especially in case of practicing compost-shed and bio-pesticides, the share of organic farmers is higher by double compared to conventional farmers. In case of conventional farmers, however, they relied on chemical fertilizers such as urea, DAP and MOP; chemical pesticides such as insecticide, weedicide and herbicides; and micronutrients such as zinc, boron, vitamin and hormones.

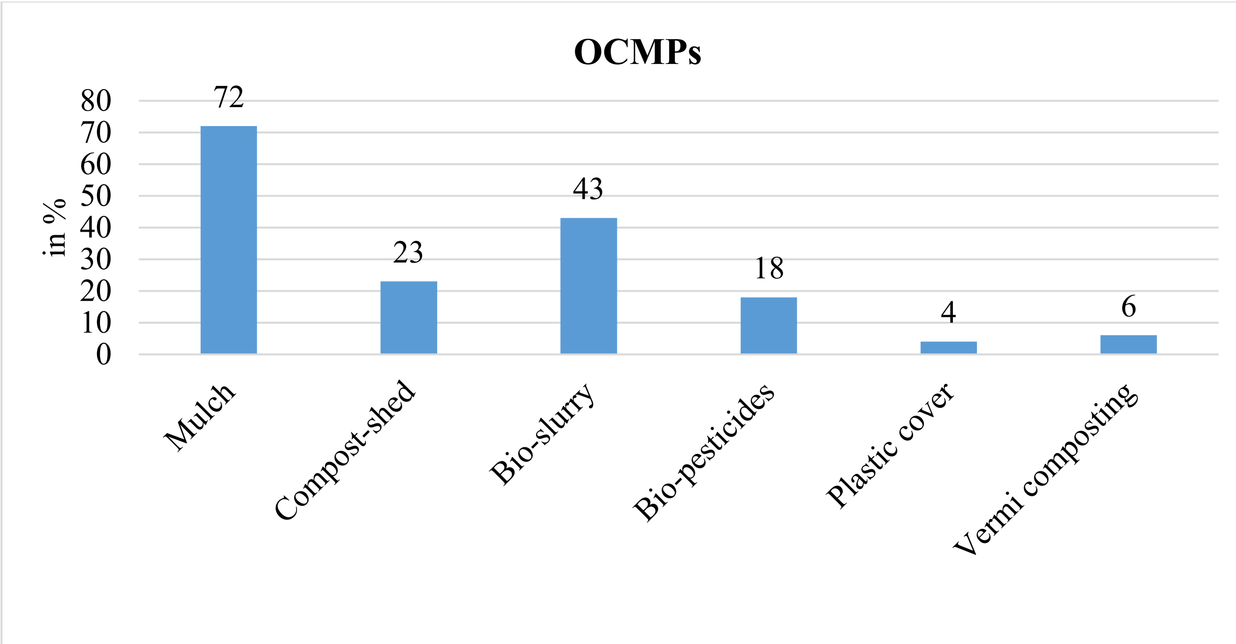

Figure 7.1 Soil fertility management practices

Source: Field survey (2013)

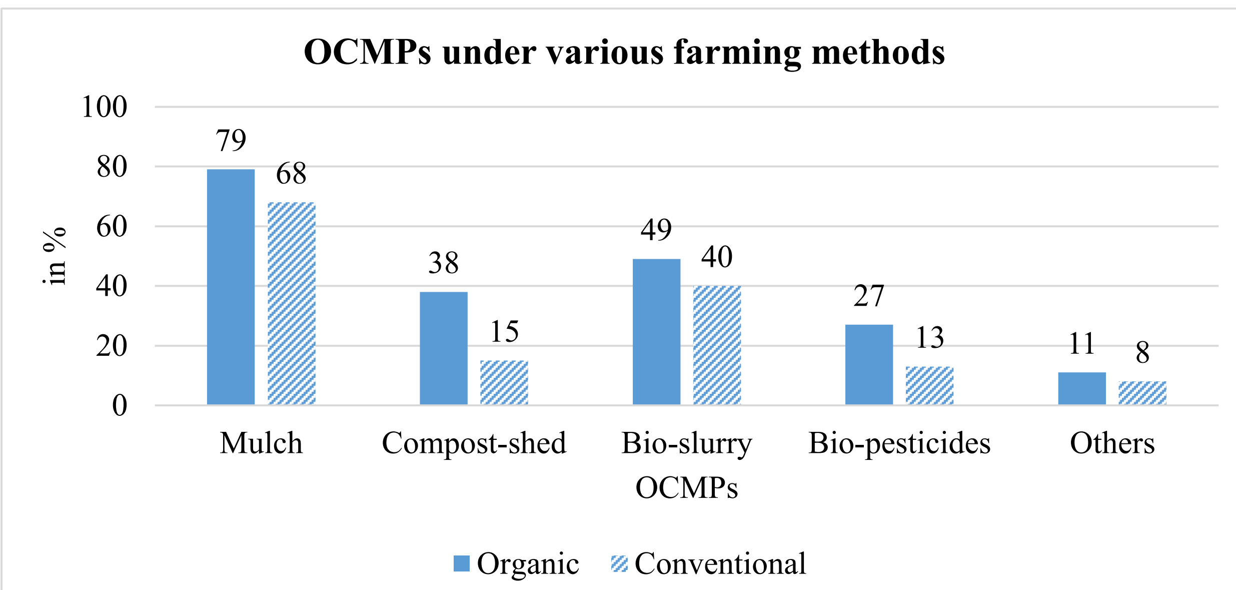

Figure 7.2 OCMPs across various farming method

Source: Field survey (2013)

7.3.2 Result from multivariate probit model

The result from MVP model is presented in Table 7.2. The likelihood ratio statistics as denoted by Wald $\chi 2$ is highly significant (p=0.0000), which shows goodness of fit, i.e., the variables sufficiently explain the model. Also the likelihood ratio test of the null hypothesis of the absence of correlation among the individual equations is strongly rejected (p=0.0000), thus justifying the rationale to estimate all equations simultaneously using MVP rather than estimating individually. Some of the directions of the signs of explanatory variables are as per the expectation and some are not. More importantly, a single variable do not have similar direction of impact across all dependent variables as was presumed to be.

Compared to conventional farmers, organic farmers have higher probability of mulching, significant at 10% and constructing compost-shed, significant at 5% level. Mulching is the most traditional way of farming which is why more of organic farmers are inclined to using it. Most of the farmers received partial funding (25% of the total cost) from a local NGO to construct the compost-shed. The fund eligibility depends on financial ability of a farmer to supply the remaining cost and active participation in the group activities. Organic farmers in the study areas have received more training as shown by previous study (Chapter 5), indicating active participation in the group activities and so they are prioritized to be recipient of such fund. However, only two farmers are selected per year and some farmers are not in a position to even finance rest of the fund, which has slowed down the adoption rate.

Table 7.2 Parameter estimates of multivariate probit model for organic means of crop management practices

Explanatory variables	**Mulch**	**P-value**	**Compost-shed**	**P-value**	**Bio-slurry**	**P-value**	**Bio-pesticide**	**P-value**	**Others**	**P-value**
farm_method	**0.41**	**0.078***	**0.58**	**0.016****	0.22	0.375	-0.01	0.959	0.07	0.829
rent	-0.25	0.216	0.18	0.402	**-0.48**	**0.015****	**0.42**	**0.061***	-0.02	0.940
org_exp	-0.01	0.524	0.01	0.656	-0.02	0.282	-0.02	0.305	0.00	0.797
LFU	-0.02	0.583	0.07	0.164	-0.06	0.283	0.04	0.405	0.01	0.834
LSU	0.02	0.698	0.01	0.882	0.05	0.305	0.06	0.291	-0.03	0.530
farm_size	0.22	0.348	**0.40**	**0.100***	0.06	0.803	-0.10	0.681	0.06	0.853
ln_farm_income	**0.21**	**0.055***	0.18	0.127	**0.67**	**0.000*****	-0.09	0.506	0.11	0.462
ln_nonfarm_income	0.01	0.507	0.01	0.492	-0.01	0.769	0.02	0.482	0.01	0.508
org_training	0.03	0.621	0.06	0.201	**0.14**	**0.014****	**0.32**	**0.000*****	0.03	0.671
credit	**0.95**	**0.009*****	0.38	0.194	-0.35	0.218	0.21	0.450	0.46	0.105
commercialization	-0.03	0.835	0.04	0.781	0.02	0.897	-0.08	0.607	0.18	0.261
constant	**-2.20**	**0.080***	**3.93**	**0.005*****	**-8.03**	**0.000*****	-0.72	0.634	**-3.07**	**0.086***

Correlation coefficients	**Coefficient**	**P-value**
$\hat{\rho}_{21}$	**0.31**	**0.006*****
$\hat{\rho}_{31}$	**-0.19**	**0.069***
$\hat{\rho}_{41}$	-0.06	0.656
$\hat{\rho}_{51}$	**0.25**	**0.053***
$\hat{\rho}_{32}$	-0.01	0.914
$\hat{\rho}_{42}$	0.02	0.901
$\hat{\rho}_{52}$	0.13	0.377
$\hat{\rho}_{43}$	0.07	0.591
$\hat{\rho}_{53}$	**0.61**	**0.000*****
$\hat{\rho}_{54}$	**0.47**	**0.000*****
Draws	100	
Number of observations	285	
Wald $\chi2$ (55)	222.73	
P-value	**0.0000*****	
Log pseudo likelihood	-623.87156	
Likelihood ratio test rho21 = rho31 = rho41 = rho51 = rho32 = rho42 = rho52 = rho43 = rho53 = rho54 = 0, $\chi2$ (10) = 42.2805, **P-value = 0.0000*****		

Note: *** at 1%, ** at 5% and * at 10% level of significance
Source: Field survey (2013)

Those who have rented the farmland in addition to farming in their own land, their possibility of using bio-slurry decreases, significant at 5% while using bio-pesticides increases, significantly at 10%. Tenant farmers are usually resource poor which is why their chances of constructing biogas that requires higher initial investment is less. Since bio-pesticides could be made from resources that are available in the farm, it could be why tenant farmers probability of using it increases, as it is cheaper than buying conventional pesticides in the market. Higher farm size results in the higher propensity of constructing the compost-shed. Constructing compost-shed too requires higher initial investment and as explained earlier, poor farmers not able to construct one even if they are offered partial cost. Farm size indicates higher resource holding which could have increased their chances of constructing a compost-shed. Those who have higher farm income, their probability of mulching and using bio-slurry increases, significant at 10% and 1%, respectively. Farm income indicates producing more crops, the residues of which could be used for mulching. Like farm size, farm income also signifies having higher resource endowment or capital availability, thus increasing possibility of installing biogas or even mulching if it is done using plastic, which requires more investment.

Training has positive impact on using bio-slurry and bio-pesticide, significant at 5% and 1%, respectively. The importance of bio-slurry and bio-pesticide is very much promoted through training conducted from the formed groups. Experience of organic farming method has negative impact on using bio-pesticide. Farmers often perceive bio-pesticides to consume time and requiring much labor during preparation and application as well. For example, it takes about 2 weeks or more to prepare bio-pesticides depending on the amount of sunlight it receives. During this time the problem of pests and disease already would have multiplied and its impact is also perceived to be slower compared to conventional means. Further they have to replace the plastic container in which to prepare bio-pesticides every few years, as its lifespan is very short. These reasons might have contributed to its lower adoption. Credit increases the probability of adopting mulching, significant at 1%. Though the credit might not have been used directly for mulching, it can have counter-effect through other activities which farmers actually used it for. For example, using credit for cultivating more crops results in more crop residue for mulching.

Estimated correlation coefficient among various OCMPs is significant for five out of ten combinations. Mulching and compost-shed are positively related and is highly significant at 1%. This means that farmers are combining these practices for soil management though both competes for crop residue. Mulching and bio-slurry are negatively related, significant at 10%. It indicates that mulching and livestock, which ultimately provides manure for biogas, competes indirectly for crop residue, thus having negative impact. Farmers are incorporating uncommon ways of soil management practices such as plastic cover and/or vermicompost with bio-slurry and bio-pesticide, significant at 1%, or even with traditional practice such as mulching, significant at 10% level. This means that those farmers who are already practicing some ways of soil or pest management practices are also incorporating not so common practices such as plastic cover and/or vermicompost.

7.4 Conclusion

Even though there is an influx of modern inputs like chemical fertilizers, pesticides and micronutrients, conventional farmers still incorporate organic means of soil fertility and pest management practices such as mulching, compost-shed, bio-slurry, bio-pesticides and plastic cover and/or vermicompost. Although adoption rate for all of such practices is high among organic farmers, indicating that organic farmers are keener on practicing various ways of sustainable soil fertility and pest management practices, especially when it comes to mulching and constructing compost-shed.

Mulching is the most traditional way of soil management practice and has higher prospect to be adopted by organic farmers as they mainly follow traditional way of farming, those having higher farm income as they will also have produced more crops which further provides more crop residue for mulching, and those who have taken credit which might not have direct impact but credit for higher investment in crop cultivation results in higher crop residue available for mulching. However in some instances the adoption can be hindered by lack of fund, such as in the case of compost-shed. Thus, it is advisable that fund assistance should be increased so as to increase the adoption rate of compost-shed by the majority. Tenant farmers have less resource holding which is why their probability of constructing biogas decreases, as it requires higher initial investment. Similarly those who have bigger farm size or higher farm income indicates being resource rich and thus their chances of adopting higher investment requiring practices such as compost-shed and biogas, respectively, too increases. This further proves that financial ability is the major drawback for the adoption of these sustainable practices. One of the ways to increase the adoption rate is training as it complements technical knowledge required to implement these practices. Also if such practices largely relies on locally available resources such as bio-pesticides, then even farmers facing financial constraint can adopt these practices such as tenant farmers.

Farmers also tend to complement most of the practices. They are practicing uncommon techniques such as plastic cover and/or vermicompost along with biogas, bio-pesticides or even with traditional ones like mulching. It indicates that any additional organic means of soil fertility or pest management practices can be introduced to those households who are already adopting one of such practices. But sometimes these practices become substitutes because of their nature of relying on the same input such as mulching and biogas directly or indirectly depending on crop residue. Thus, any effort to enhance such adoption rate can consider these characteristics of various practices. Hence, adoption of organic means of crop management practices is influenced in different ways by various socio-economic factors, which should be regarded before any intervention.

Chapter 8. Farm income and gross farm cash income

8.1 Introduction

Conventional farming is known for its profit orientation. Although massive breakthrough in agricultural technologies backed by modern plant breeding, improved agronomy, and the growth of conventional fertilizers and modern pesticides brought remarkable changes in food productivity (IFPRI, 2002), such conventional means of production was later criticized because it brought environmental, economic and social concerns (DFID, 2004; Kassie & Zikhali, 2009). Organic farming on the other hand is conceived to be a sustainable alternative to conventional farming. It embraces local resources in combination with modern scientific knowledge to sustain the health of soil, ecosystem and people (IFOAM, 2014a). In the growing context of climate change, organic farming is praised for its ability to be resilient and at the same time mitigate and adapt to the changing climate (IFOAM, 2009). Organic farming, though provides social and environmental benefits, the argument over monetary return is the major bottleneck for its large-scale adoption.

In case of organic farming, it is the probability of getting price premium that makes this endeavor a profitable one than conventional farming. In many scenarios, income increase through improved yield along with the combination of reduced cost. But it is the premium that attract farmers to shift to organic farming, which usually makes up for any yield or productivity losses that may incur during the transition (Giovannucci, 2005). In Nepal, in addition to the export market for organic products (Pokhrel & Pant, 2009; DoAE, 2006; Tamang, Dhital, & Acharya, 2011), local market in urban areas is also on rise (FiBL & IFOAM, 2009; FiBL & IFOAM, 2010). However, marketing is usually done unsystematically on the basis of community trust (Sharma, 2005). Farmers are able to get premium price based on this mutual trust irrespective of the fact that the product is not certified. And in some cases, though the farm is certified, farmers are not able to get premium price because of poor marketing method and skill (Singh & Maharjan, 2013). Thus, the profitability of organic farming through access to premium market cannot be simply explained by the fact that it is certified especially in the context of local market in Nepal.

The objective of this study is to analyze first the difference in farm income between organic and conventional farm. Because farm income includes valuation of overall farm output from crops and livestock that were sold in the market and those self-consumed as well, it gives us complete picture of how organic and conventional farm is contributing to household farm income. The second objective is to analyze market involvement of organic farmers for the purpose of selling crops and an extent to which they are able to generate income thereof. The purpose is also to compare with conventional farmers so as to evaluate how it performs comparatively by taking into consideration the existence of premium market, either local or export based. By analyzing the difference in the level of income received under various farming methods, we will be able to understand the opportunities and challenges of market for organic products. The monetary income gained from selling crops in the market is termed as gross farm cash income (hereafter referred to as 'cash income'), i.e. the monetary income obtained from selling cereals, vegetables, spices, pulses, oil seed and/or fruits in the market without deducting the cost.

Farm households can be observed as an autonomous entity that has capacity to make decision to the best of their interest considering their limited resources. Therefore, the study also assesses various demographic and farm characteristics of farmers to analyze their impact on farm income and their ability and preparedness to sell crops in the market for monetary income. Recognizing such traits will assist in making organic farming monetarily attractive for the farmers.

8.2 Methodology

8.2.1 Variables selection

The primary issue of this chapter is to analyze how income from organic farm would compare with conventional farm. Both farm income and cash income is regarded to be impacted in a similar way by households' socioeconomic characteristics, as it is eventually the income we are concerned in assessing. As mentioned above, premium price is the most attractive feature for organic farmers but from the field survey it is known that the premium market for organic products in the local area is non-existent.

Some farmers are able to export their produces in other cities where premium market does exist (Table 8.1). Such market is only limited to cereal crops such as rice, maize, wheat and buckwheat, and other non-perishable or with longer shelf life crops/products like kidney bean, carrot and honey. Most vegetables, as of present, could not be exported due to its easily perishable nature and lack of other facilities to maintain its quality. However, currently only 7% of the crops produced organically are sold in the premium market. As for the rest, they are sold in the local market at the same price as conventional products. With this scenario, it is expected that organic farmers could have either higher or lower income compared to the conventional farm (Table 8.2).

Table 8.1 List of organic products sold by a cooperative in Phoolbari VDC in 2069 B.S. (April-May 2012/ March-April 2013)

SN	Item	Quantity sold (kg)	Price (NRs./kg)	Total production (kg)*	Sold (%)	Regular price (NRs./kg)	Premium (%)
I.	**Cereals:**						
1	Chamal (Husked Rice)	1850	57	100866 (unhusked rice)	6	50	14
2	Dhan (Unhusked Rice)	4000	22			20	10
3	Makai (Maize)	500	31	19932	3	18	72
4	Gahu (Wheat)	1450	30	2440	59	18	67
5	Fapar (Buckwheat)	1200	60	1595	75	25	140
II.	**Pulses:**						
6	Rajma (Kidney bean)	605	120	2053.5	29	70	71
III.	**Vegetable:**						
7	Gajar (Carrot)	5000	12	78407	6	11	9
	Total	**14605**	**-**	**205293.5**	**7**	**-**	**-**
IV.	**Others:**						
8	Maha (Honey)	121.5	300	(no data)	-	-	-

Source: Field survey (2014)

Note: Total production (kg)* signifies total amount of respective crops produced organically by only those (organic) farmers who are member of the cooperative through which they are sold at the premium market in other cities.

Several literatures were reviewed to hypothesize the influence of selected demographic and farm characteristics related variables on the income. Education might have a negative impact on a farm cash income, but probably not on the total income since more educated people switch occupation to be better compensated for their work. On the other hand, it could also have impacted positively on agricultural productivity and indirectly as an external source of income for risk aversion and to overcome credit constraints in farming (Mahmudul, Ishida, & Taniguchi, 2003; Weir, 1999). Similar relation of non-farm income to income from farm activities is expected, that is it could either reduce the significance of having to earn through farm activities or it could actually contribute as a credit relief or financial support for expanding the marketing activities. Family size has positive effect on farm income, as it indicates labor availability for performing farm activities and hence increases the farm productivity and income (Adil, Badar, & Sher, 2004; Parvin & Akteruzzaman, 2012). Livestock has positive effect on farm income as it is meant to improve productivity (Adil, Badar, & Sher, 2004). Farm size also has positive relation to farm income as people who have more land can produce more crops and earn more money from selling the crops (Rahman, 2010; Mahmudul, Ishida, & Taniguchi, 2003).

Various other factors such as membership and training are expected to complement the capacity, skills and information required for improving farm income as shown by Adil, Badar, & Sher (2004) that complementary factors like seed, fertilizer and irrigation cost can have positive effect on income of farmers. In this regard, agrovet and market are also important associations through which farmers can improve their farming performance by having easy access to farming performance enhancing inputs or getting information on market scenario, hence contributing to increase the income. Thus, farther these associations are to the farm household, lower the farm income is to be expected. Farmers who used the credit facility (borrowed the money) allocated more land to different crops and fruit varieties compared to non-borrowers. This had a positive effect on crop yield and thus increased income significantly (Shah, Khan, Jehanzeb, & Khan, 2008).

Table 8.2 Hypothesized relation of explanatory variables

Variables	Expected sign	References
farm_method	+ve/-ve	Own elaboration
HHHgender	+ve	Own elaboration
HHHage	-ve	Own elaboration
HHHedu	+ve/-ve	Mahmudul, Ishida, & Taniguchi (2003); Weir (1999)
HHHprimary_occu	+ve	Own elaboration
rent	-ve	Own elaboration
org_exp	+ve	Own elaboration
LFU	+ve	Own elaboration
LSU	+ve	Adil, Badar, & Sher (2004)
farm_size	+ve	Rahman (2010); Mahmudul, Ishida, & Taniguchi (2003)
ln_nonfarm_income	+ve	Adil, Badar, & Sher (2004); Parvin & Akteruzzaman (2012); Mahmudul, Ishida, & Taniguchi (2003); Weir (1999)
membership	+ve	Adil, Badar, & Sher (2004)
org_training	+ve	Adil, Badar, & Sher (2004)
VDC	+ve	Own elaboration
agrovet	-ve	Adil, Badar, & Sher (2004)
market	-ve	Adil, Badar, & Sher (2004)
credit	+ve	Adil, Badar, & Sher (2004); Parvin & Akteruzzaman (2012); Mahmudul, Ishida, & Taniguchi (2003); Weir (1999); Shah, Khan, Jehanzeb, & Khan (2008)
final_price	+ve	Own elaboration
commercialization	+ve	Own elaboration
SHDI	+ve	Padmavathy & Poyyamoli (2012)

Besides these, other variables considered are gender of HHH, age of HHH, experience of practicing organic farming, primary occupation of HHH, HH tenancy status, labor availability, belonging to Phoolbari VDC, knowing the price of crops paid by the consumers, commercialization rate and SHDI. Except for age of HHH and tenant farmers, all are expected to have positive relation to income. It is presumed that male-headed households would be more competitive towards earning higher income. With higher experience of organic farming, it is supposed that farmers would have become skilled on various practices to improve production and getting access to premium market, and thus the income. They would also have gained knowledge on marketable values of organic products and would be involved more into selling. Farmers who rely on farming as their primary occupation would be more determined to earn higher income. Higher labor means higher manpower to contribute in farm activities including production and marketing the crops. Farmers in Phoolbari VDC are expected to have higher income than those in other two VDCs because at present premium market is mainly accessible to farmers in this VDC. On the other hand, farmers who know the price of crops paid by the consumers make informed decision on which crops to produce and market. It is thus expected to have positive impact on the farm income. It is apparent that commercialization rate will increase income but this study tries to assess the marginal impact of commercialization on income. A study by Padmavathy & Poyyamoli (2012) showed that organic farm will have higher gross income because of higher diversity and so higher SHDI is expected to have positive impact on the income. Age of HHH is believed to have negative impact on income because with age one's capacity to work declines which could impact on production and marketing activities. Finally tenant farmers who are known to be resource poor, their ability to invest in production enhancing inputs is perceived to be low. Similarly, since they will have to pay half of their produce as a rent, they will be left with very less or no crops for selling in the market, thus decreasing cash income as well.

8.2.2 Empirical model

First, this study analyzes factors impacting farm income between organic and conventional farm. OLS model is used to see this relation, which can be expressed as:

$$y_i = \beta_0 + x_i\beta_i + \varepsilon_i \quad (8.1)$$

where y_i = farm income, x_i = socioeconomic variables, i = number of observations, β_0 = coefficient of intercept, β_i = parameter to be estimated, and ε_i = error term.

The empirical specification for OLS model can be given by:

$$\text{ln\_farm\_income} = \beta_0 + \beta_1 \text{ farm\_method} + \beta_2 \text{ HHHgender} + \beta_3 \text{ HHHage} + \beta_4\text{HHHedu} + \beta_5\text{HHHprimary\_occu} + \beta_6\text{rent} + \beta_7\text{LFU} + \beta_8\text{LSU} + \beta_9 \text{ farm\_size} + \beta_{10}\text{ln\_nonfarm\_income} + \beta_{11}\text{org\_training} + \beta_{12}\text{VDC} + \beta_{13}\text{agrovet} + \beta_{14}\text{market} + \beta_{15}\text{credit} + \beta_{16}\text{SHDI} + \varepsilon \quad (8.2)$$

where ln is natural log.

Secondly, this study assesses gross farm cash income at individual household level. The sample is such that there are number of households who are not engaged in selling their farm products, meaning they utilized their produces solely for own household consumption. Table 8.3 shows that 79% of the households sell their produce in the market while 21% of them produce for their own household consumption only. On average households generated cash income worth NRs. 107,420 per ha from selling crops in the market.

Table 8.3 Measurement and summary of dependent variables

Dependent variables	Definition and Measurement	Bivariate probit model	OLS model
		Mean±Standard deviation/%	
cash_income	Income generated from selling crops in the market; 1=yes, 0 otherwise	79%	-
cash_income per ha	Income generated from selling crops in the market (without deducting cost of production); in NRs.	-	107419.6± 105576.1

Source: Field survey (2013, 2014)

As a result, although OLS is the most frequently used model for fitting the regression line, it could give biased parameter estimates arising from a missing data problem. The Heckman selection model has been introduced to address this problem of sample selection where only partial observation is made from the outcome variable (Heckman, 1979). It estimates a two-stage model. The first one is called selection equation (or probit model), which shows the impact of explanatory variables on probability of whether household earns cash income or not from selling crops. The second one is called outcome equation (or OLS model) that predicts the impact of explanatory variables on the degree to which households are able to earn as a result of selling crops. The second stage also includes an additional (control) variable called the inverse Mills ratio that is derived from the probit estimate (or the first model). An inverse Mills ratio or lambda is the ratio of the probability density function to the cumulative distribution function of a distribution and is used to reflect the issues of possible selection bias.

However, when this model was applied in our data, it gave lambda value (14865.2) with insignificant p-value (0.482). Since lambda is a product of rho and sigma (where rho is the correlation between errors in the selection and outcome equations and sigma is error from the outcome equation), it can be implied that the problem of sample selection bias remains minimal. According to Kennedy (1998), the trivial correlation between errors of the outcome and selection equations is one of the reasons why the Heckman model does not perform well. In such case with no selectivity bias, the two methods can be analyzed separately (probit for the probability of being selected and OLS on the non-censored observations).

Thus, bivariate probit model (BPM) for assessing socioeconomic variables' impact on cash income can be expressed as:

$$y_j^* = \beta_0 + x_j\beta_j + e_j \qquad (8.3)$$

$$y_j = \begin{cases} 1 & \text{if } y_j^* > 0 \\ 0 & \text{otherwise} \end{cases} \qquad (8.4)$$

where j is number of observations, y* is the unobservable latent variable, y is binary variable of whether a household earns cash income from selling crops or not, x is socioeconomic characteristics of a household, $\beta_0$is coefficient of intercept, β_i is parameter to be estimated and e is the normally distributed error term.

Marginal effect for BPM is given by:

$$\frac{\partial P\ (y_j=1/x_j)}{\partial x_j} = \varphi\left(x_j\beta\right)\beta \qquad (8.5)$$

where φ is distribution function for the standard normal random variable.

The empirical specification for BPM can be given by:

$$\text{Market involvement} = \beta_0 + \beta_1\text{HHHgender} + \beta_2\text{HHHedu} + \beta_3\text{HHHprimary\_occu} + \beta_4\text{rent} + \beta_5\text{LFU} + \beta_6\text{LSU} + \beta_7\text{farm\_size} + \beta_8\text{ln\_farm\_income} + \beta_9\text{membership} + \beta_{10}\text{credit} + \beta_{11}\text{final\_price} + e \quad (8.6)$$

Where, ln is natural log.

OLS model for assessing socioeconomic variables' impact on intensity of cash income earned by a household can be expressed as:

$$y_k = \acute{\beta}_0 + x_k\acute{\beta}_k + \mu_k \quad (8.7)$$

where k is number of observations, y_k is observed values of gross farm cash income, x_k is socioeconomic characteristics of HHs, $\acute{\beta}_0$is coefficient of intercept, $\acute{\beta}_k$ is parameter to be estimated and μ_k is the error term.

The empirical specification for OLS model can be given by:

$$\text{Gross farm cash income} = \beta_0 + \beta_1\text{ farm\_method} + \beta_2\text{ rent} + \beta_3\text{ LFU} + \beta_4\text{ln\_farm\_income} + \beta_5\text{VDC} + \beta_6\text{market} + \beta_7\text{final\_price} + \beta_8\text{ commercialization} + \mu \quad (8.8)$$

where ln is natural log.

As per the regression rule, diagnostic tests were carried out to check the problem of multicollinearity and heteroscedasticity in the data. After regressing for farm income, market involvement for BPM and cash income for OLS model, the VIF gave a value below 10 (Appendix VI), indicating multicollinearity among the variables does not exist. Likewise, Breusch-Pagan/Cook-Weisberg showed significant P-value for all there, thus rejecting null hypothesis of homoscedasticity. It means that there are linear forms of heteroscedasticity. Again White's test did not show significant P-value for all three, implying that there is no problem of non-linear forms of heteroscedasticity, i.e., the variance of the error term is constant. To correct heteroscedasticity of any kind, model estimation was conducted using robust standard errors. An endogeneity test between farm income and farm size was carried out. But the Hausman test showed insignificant residual value, which is why simple OLS model is used instead of estimating instrumental variables.

8.3 Results and discussion

8.3.1 Result from ordinary least square model

The P-value of the OLS regression for farm income as a whole is highly significant at 1%, which supports the existence of a relationship between explanatory and dependent variables (Table 8.4). Compared to conventional farm, organic farm has lower farm income by 11%, though not significant. This means that the farm income is not statistically significantly different among the two farming methods. Male-headed households are more competitive in earning higher income, thus those households headed by men have 9% higher farm income. A year increase in age of HHH will actually increase farm income by 1%, which is opposite to previous hypothesis. It could be that with age comes expertise in various activities leading to higher farm income. A year increase in formal education will increase farm income by 2%, significant at 10%, because with education comes one's ability to take better decisions. Farmers whose primary occupation is farming has farm income higher by 37%, significant at 1%, which indicates that such farmers would be more determined about improving their farm income to support the family. Those who have rented in farmland will have farm income higher by 10%, which is again against our hypothesis. It could be that tenant farmers will have to produce more to pay rent in kind and to be self-sufficient in household food consumption as well. This might make them competitive to produce more and hence the higher farm income but it does not necessarily indicate their well-being.

Contrastingly, labor showed negative relation to farm income. A unit increase in LFU will decrease farm income by 0.4%. It could be because labor, especially young generations and men, are directed more towards non-farm sector and thus it is not a defining factor anymore for explaining vibrancy in farm activities and hence the income. A unit increase in LSU and farm size increases farm income by 12% and 74%, respectively, both significant at 1%. Higher livestock holding means higher manure availability that improves production and bigger farm size means larger area to accommodate more crops. A percent increase in non-farm income will decrease the farm income by 1%, suggesting that non-farm income is being invested in sectors other than farming. Training complements the knowledge required to improve farm income and thus one more training would lead to 3% increase in farm income. Farmers in Phoolbari VDC has farm income less by 14% compared to those in other VDCs, though not significant. A kilometer distance to agrovet and market increases farm income by 1% and 4%, respectively, the latter significant at 1%. This is opposite to what was perceived earlier. It could be that with longer distance to such associations, farmers would cultivate varieties of crops prioritizing self-consumption because modern inputs offered by agrovets would not be easily accessible and it would cost farmers while commuting in the market for buying. Cultivation of various crops could incorporate higher value crops as well which could lead to higher valuation of farm output. Again credit and SHDI increases farm income by 21% and 46%, respectively, the latter being significant at 1%. Credit ensures accessibility of various options that enables increase of farm income. Similarly, higher SHDI indicates assimilating crops of higher market value as well, thus increasing the farm income.

Table 8.4 Result from OLS model for farm income

Variables	Coefficient	P-value
farm_method	-0.11	0.336
HHHgender	0.09	0.615
HHHage	0.01	0.201
HHHedu	**0.02**	**0.054***
HHHprimary_occu	**0.37**	**0.001*****
rent	0.10	0.327
LFU	-0.004	0.890
LSU	**0.12**	**0.003*****
farm_size	**0.74**	**0.000*****
ln_nonfarm_income	-0.01	0.235
org_training	0.03	0.309
VDC	-0.14	0.156
agrovet	0.01	0.616
market	**0.04**	**0.005*****
credit	0.21	0.195
SHDI	**0.46**	**0.008*****
constant	**9.14**	**0.000*****

Note: *** 1%, ** 5% and * at 10% level of significance

Number of observations = 285 **Prob > F = 0.0000*****

F (16, 268) = 8.43 R-squared = 0.3899 Root MSE = 0.735

8.3.2 Result from bivariate probit and ordinary least square model

For the second objective of assessing market involvement and gross farm cash income, the P-value for the regression as a whole is highly significant at 1% for both BPM and OLS model which supports the existence of a relationship between explanatory and dependent variables. The Pseudo R^2 and R^2 value suggests that 25% and 55% of the total variation in the values of dependent variables is explained by the independent variables in BPM and OLS model, respectively (Table 8.5).

Most of the variables showed expected direction of sign except for some, among which are gender of HHH, labor availability, livestock holding and group membership. Contrast to what was assumed, all of these variables actually contribute negatively to the probability of selling crops by 9%, 2%, 2% and 8%, respectively. It is especially men who are engaged in non-farm activities for better opportunities. They work as teachers, carpenters, etc. within the local area or migrate in other cities or countries as well. This has shifted the direction of how male-headed households would behave in engaging in selling crops in the market. Adverse impact of labor on the likelihood of selling crops implies that labor force is being directed more towards non-farm activities rather than complementing as an investment for farm activities such as marketing. It also complements the earlier explanation of male-headed households being attracted towards non-farm sector. This is somehow also true for younger generations who act less as a helping hand for farm related activities and are receiving education to prepare themselves for occupation other than farming. Livestock rearing takes space and time, which might have led to reduced share of land for crop cultivation and less time available for marketing the crops.

Table 8.5 Result from Probit model for marketing crops and OLS model for gross farm cash income

Variables	Selection equation (Probit model)			Outcome equation (OLS model)	
	Coefficient	P-value	Marginal effect	Coefficient	P-value
farm_method				**-13250**	**0.019****
HHHgender	-0.54	0.145	-0.09		
HHHedu	0.03	0.143	0.01		
HHHprimary_occu	0.27	0.264	0.058		
rent	**-0.56**	**0.010*****	**-0.14**	**-12393**	**0.036****
LFU	**-0.10**	**0.050****	**-0.02**	**-2459**	**0.062***
LSU	**-0.11**	**0.071***	**-0.02**		
farm_size	**0.90**	**0.053***	**0.19**		
ln_farm_income	**0.54**	**0.000*****	**0.12**	**17933**	**0.000*****
membership	**-0.37**	**0.050****	**-0.08**		
VDC				**9287**	**0.100***
market				-1340	0.113
credit	**0.65**	**0.096***	**0.10**		
final_price	**0.89**	**0.011****	**0.15**	**11412**	**0.086***
commercialization				**49291**	**0.000*****
constant	**-4.95**	**0.001*****		**-170857**	**0.000*****
No. of observation	285				225
Wald chi^2 (11)	55.96				
Log pseudo likelihood	-109.94				
Prob > chi^2	**0.000*****				
Pseudo R^2	0.2505				
F (8, 216)					40.53
Prob > F					**0.000*****
R-squared					0.5474
Root MSE					38496

Source: Field survey (2013)
Note: *** at 1%, ** at 5% and * at 10% level of significance

Group membership, through which farmers have access to premium market, reduces likelihood of marketing the crops by 8%, significant at 5%, which could be due to the combination of various reasons. As shown in Table 8.1, there is very limited demand for both crop varieties and quantities to be sold in the premium market. Currently only 6 crops (rice, maize, wheat, buckwheat, kidney bean and carrot) are sold through a cooperative, accounting for only 7% of the production (of those

6 crops) with premium ranging from 9-140%. However, there is no significant contribution of premium price in overall income for these 6 crops (Table 8.6). The rest are sold in the local market at same price as conventional products in which case organic products are often at the losing end as some farmers claimed that the organic vegetables usually are disfigured, dull colored with less brightness/shine, smaller in size and even have small holes from pest attack. Although some said that if enough fertilizer is used, the size of production is not different and some had the opinion that smaller size might be the result of growing vegetables during off-season.

Although member farmers are given marketing related training, it is mainly confined to basics such as presentation of organic agro-products for visual attraction, informing consumers of health benefits of consuming organic, and information of few premium markets in other cities which is outside their jurisdiction. In this case, forming market linkage has been particularly challenging for farmers. The limited access to premium market is a result of years of associating with various stakeholders that too comes with various challenges. Farmers have limited to dealing with few dealers to take their produces to be sold in the premium market because previously they had experience of such dealers mixing their products with conventional ones so that more quantities could be sold at the premium market as organic. That is why farmers have carefully relied on only few dealers whom they can build trust. However, the drawback of such marketing is the payment received by farmers is too late which is a sensitive matter for them, as they have to rely on income from one season to invest in another season. Moreover, they have also had an unpleasant experience of losing from mass cultivation of *Tulsi* (Ocimum tenuiflorum L.), which they produced with the intention of selling it to a private organization who intended to export it. But later since the market price considerably went down, the private organization discarded the whole dealing, leaving most of the farmers with no option but to utilize the crop as green manure. This is also the reason why many farmers hesitate to participate in the premium market but rather sell their produce in the local market even though it means ‘no premium’. In the local area, very recently there has been influx of shops selling organic or eco-friendly agro-products. But so far majority of farmers are not aware of it.

Table 8.6 Comparing cash income across two farming methods from 6 crops that were partly sold in the premium market

Crops	Farming method (Mean±SD)						T-test
	Organic	**n**	**Conventional**	**n**	**Total**	**N**	
Sold_rice	24591.36± 21275.01	44	34710.23± 35674.07	87	31311.53± 31853.26	131	**0.086***
Sold_maize	7781.053± 8552.007	19	7932.456± 11844.1	57	7894.605± 11059	76	0.959
Sold_wheat	7180± 10346.36	8	6125.455± 4232.738	33	6331.22± 5765.859	41	0.648
Sold_buckwheat	2962.909± 3081.677	11	4000± 3605.551	3	3185.143± 3082.239	14	0.625
Sold_kidneybean	10360.29± 11249.72	17	19319.74± 52738.88	38	16550.45± 44280.07	55	0.493
Sold_carrot	41659.09± 48677.1	11	93824.35± 139994.8	31	80162.02± 124326.9	42	0.236

Source: Field survey (2013)
Note: * at 10% level of significance

One additional year of formal education will increase the probability of selling crop/s in the market by 1% as they will have better access to information and be more knowledgeable about the market scenario. Those whose primary occupation is farming, their likelihood of selling crops in the market increases by almost 6% as they would be more determined to earn higher income. Farmers who have rented in the farmland in addition to farming in their own land will have decreased probability of marketing crops by 14%, significant at 1%, because of having to pay half of their produce as a rent, thus leaving them with very less or no crops for selling in the market. A hectare increase in farm size will increase the prospect of marketing crops by 19%, significant at 10%, as larger farm can accommodate excess crops to sell in the market after household consumption (Rahman, 2010; Mahmudul, Ishida, & Taniguchi, 2003). A percent increase in farm income also increases the possibility of crop selling by 12%, significant at 1% because higher monetary valuation of crops will encourage farmers to sell for higher profit. Access to credit also increases probability of marketing crops by 10%, significant at 10%, as they will have means to be able to act in a way that improves their accessibility to the market (Shah, Khan, Jehanzeb, & Khan, 2008). Those farmers who are updated about the information on final price at which their products are sold to consumers shows increased probability of selling crops by 15%, significant at 5%, which shows that they would be more interested in selling.

The result from OLS model shows that compared to conventional farmers, organic farmers tend to earn NRs.13,250/ha less cash income, significant at 5%. In this case, organic farmers have less production from all the crop categories except fruits (Figure 8.1), have less commercialization rate (Figure 8.2) and per unit price received except cereals (Figure 8.3). As mentioned above, only few organic farmers are able to get premium price ranging from 9-140% but only 7% is sold out of those 6 crops which are currently traded in the premium market. Thus, it is not able to make any significant difference in the overall per unit price received by farmers and hence the income generation of organic farmers. Farmers who have rented farm in addition to having their own farmland have cash income less by NRs.12,393/ha, significant at 5%, compared to those who fully own the farmland. A unit increase in LFU decreases cash income by NRs. 2,459/ha, significant at 10%. This also supports the fact that labor is directed more towards non-farm sectors. A percent increase in farm income increases cash income by NRs. 17,933/ha, significant at 1%. Farmers of

Phoolbari VDC have cash income higher by NRs.9,287/ha, significant at 10%, compared to those in other two VDCs. A kilometer distance to the market will decrease cash income by NRs. 1,340/ha. Knowing final price of product at which consumers buy increases farm cash income by NRs. 11,412/ha, significant at 10%. Finally, commercialization rate increases cash income by NRs. 49291/ha, significant at 1%.

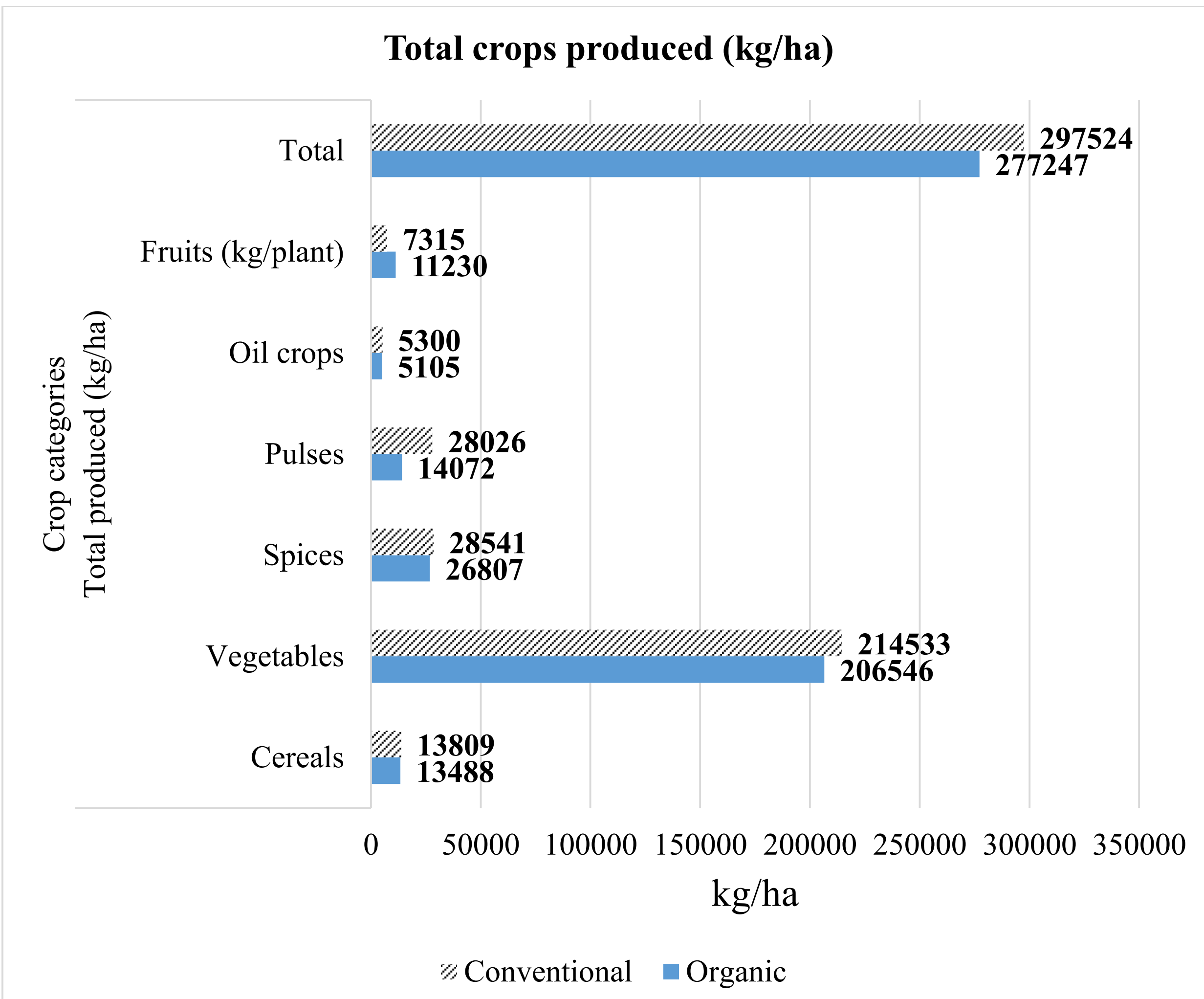

Figure 8.1 Total crops produced (kg/ha) under two farming method

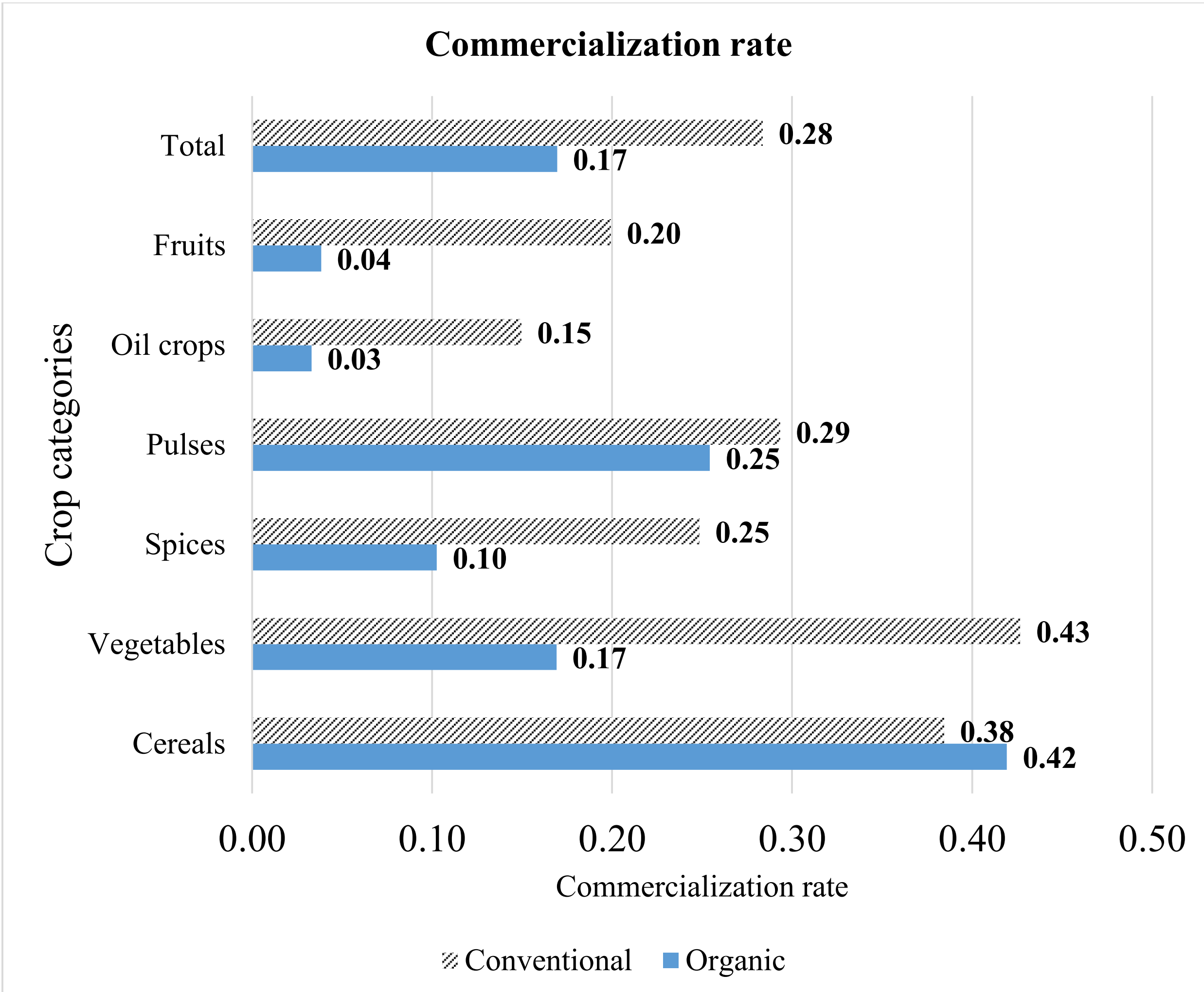

Figure 8.2 Commercialization rate under two farming method

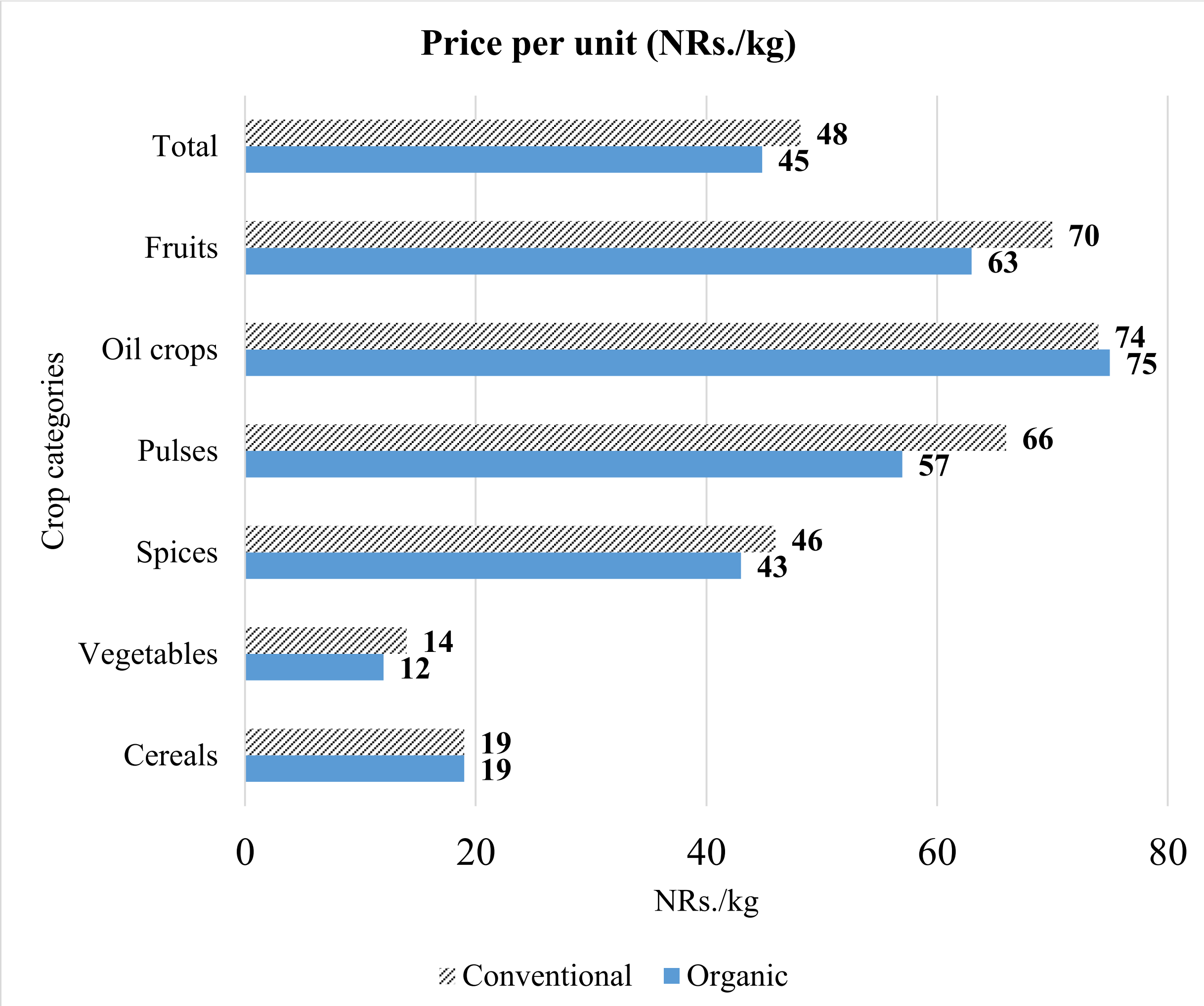

Figure 8.3 Price per unit of crop under two farming method

8.4 Conclusion

Education of HHH, farming as primary occupation of HH, livestock holding, farm size, farther distance to market and SHDI contributes positively in increasing farm income or market valuation of farm output. As for selling crops in the market, farm size, farm income, credit and knowing final price at which the consumer buys increases its likelihood while tenant farmers, labor availability, livestock holding and group membership decreases it. Farm size results in increasing the probability of being involved in marketing which means that subsistence farming might be at the losing end when it comes to earning through farm activities. Increasing farm size through merging and collaboration can also encourage selling crops in the market. Providing access to credit will also help access the means that allows farmers to be engaged in marketing their crops. Market information of crops' price at which consumers buy encourages farmers not just to be involved in marketing their crops but also to subsequently increase their cash income. Thus, such information should be disseminated among farmers to improve their cash income generating capability. Tenant farmers have to give away their produce as payment of rent and thus will have lesser or no amount left for marketing and to increase the cash income. Unlike the previous assumption that labor supply positively influences intensity of farm activities, including being involved in marketing crops or generating higher amount of farm cash income, this study shows that labor is not any more the defining factor because it is being diverted to non-farm sector. Livestock holding takes up more space and time, leaving farmers with less area for crop cultivation and less time for marketing.

Conventional farmers still earn higher income than organic farmers because at present, the production per hectare, commercialization rate and price per unit for almost all the crops is higher for conventional products. In addition to that, access to the premium market is very limited and has not been able to make any significant contribution to farmers' income. Since monetary benefit can attract farmers to divert their labor force in farming activities and specifically to boost income pertaining to organic farming, making access to premium market is very imperative. Organic farmers should be linked with potential sellers not just in other cities but in the local area as well where few shops have just been commenced to sell the organic products so that the farmers would have more control over the price and quality check of their products.

Chapter 9. Production and net return from carrot production

9.1 Introduction

Organic farming is known for being a sustainable food production method that relies on agro-ecological principles resulting in improvement of soil fertility rather than depleting it, which often is the case in conventional farming method. With intensifying issue of climate change, the contribution of organic farming to mitigate and adapt to the changes has further boosted its potential (Scialabba, 2007). It also ensures a safe working environment by the avoidance of use and hence the exposure to harmful chemicals and providing residue free products to the consumers (ESCAP, 2012; Vaarst, 2010). Although organic farming provides social and environmental benefits, its economic benefit is often debatable when compared to conventional farming. According to Ramdhani and Santosa (2012), economic justification plays an important role for smallholder farmers than social and environmental benefits to sustain with their farming enterprise in a long run. Especially in developing countries, income still plays a vital role followed by environmental, technological, social and political aspects. Therefore, to increase the share of organic farming, which as of 2013 comprises of 0.98% of the overall agricultural land (including in-conversion areas) in the global context and only 0.2% in Nepalese context (FiBL & IFOAM, 2015), ensuring economic benefit is very much essential.

There are various theories to justify the yield and overall economic benefit of organic and conventional farming methods. The evolution of farming through the use of modern inputs has been successful in increasing production in various parts of the world. But the use of costly inputs has put a strain on the overall return or its actual economic benefit (FAO, 1996; Hazell & Wood, 2008). Organic farming is a cost effective and affordable farming method that does not require expensive technical investment but rather relies on locally available resources (Leu, 2011). As for the production, it is claimed that in order for it to be comparable, increasing cultivated area under organic farming is inevitable. Another challenge is to supply enough organically acceptable fertilizer which is difficult to acquire (Trewavas A. , 2002; Meisner, 2007). The most important aspect of organic sector is it can generate premium price in an established market that ultimately generates more profit. Therefore, often times, the income under organic method is better, exclusively or in combination with improved yields, reduced costs or premium price which can compensate for any yield losses that may incur during the transition phase (Giovannucci, 2005). This study is conducted to compare economic benefit from organic farming with respect to conventional farming and analyze input factors contributing to it. In doing so, the study compares the cost components of production factors and analyzes the net return from organic and conventional carrot which is the most commercially cultivated non- staple crop in the study areas, as identified through key informant interview. The study also looks into the impact of various socioeconomic factors leading to such level of production.

9.2 Methodology

9.2.1 Sample selection

The final sample size for the analysis of organic and conventional carrot growers is shown in Table 9.1. The data is generated based on the recollection of farmers on carrot cultivation of past one year. Since there were more carrot growers in Phoolbari VDC, more than 50% of the respondents belong to this VDC. Similarly, organic carrot growers are more in Phoolbari VDC and conventional carrot growers are more in other VDCs in our finalized sample. Approximately 52% of the respondents are member of a group formed for the purpose of organic farming. Most of the organic growers (82%) have membership while some 37% of conventional carrot growers are members of such group too.

Table 9.1 Total members in group and sample number of organic and conventional growers

VDC	Organic (n=63)	Conventional (n=45)	Total	P-value
Phoolbari	19 (70.37)	25 (46.30)	44 (54.32)	0.040**
Others	8 (29.63)	29 (53.70)	37 (45.68)	
Membership				
Yes	22 (81.48)	20 (37.04)	42 (51.85)	0.233
No	5 (18.52)	34 (62.96)	39 (48.15)	

Source: Field survey (2013)
Note: ** 5% and * at 10% level of significance

9.2.2 Variables selection

Table 9.2 shows the expected relation of socioeconomic variables on the carrot production. As explained before, production under organic farming is known to be less compared to conventional farming unless we can increase the area of land under organic. On the other hand, it is difficult to access enough inputs that are acceptable as organic (Trewavas A. , 2002; Meisner, 2007). Contrastingly some studies have shown organic production to result in yield equal to or higher than that of conventional if practiced in an effective way. A study done on organic farming and the global food supply showed that organic production method has the capacity to sustain current or even larger human population without increasing the agricultural land base, emphasizing the importance of leguminous cover crops for effective results (Badgley, et al., 2007). Thus, organic farming could result in either positive or negative effect on the carrot production.

In farming, men are expected to produce more than females not because they are more efficient, but because females are often deprived of accessing productive resources and opportunities. Compared to males, they control less land, use fewer inputs and have less access to important services such as extension advice (FAO, 2015). With age, one's ability to garner physical strength diminishes, thus eventually decreasing the agricultural production. But on the other hand, they are experienced on utilizing labor more effectively through efficient combinations of input (Guo, Wen, & Zhu, 2015). Thus, the direction of this variable in the crop production could go either way. Education is one of the most important factors contributing in the development of the agricultural sector. Educated farmers have better access to information and utilize it for producing better results. Livestock holding and farm size are indicators of wealth status in rural areas and thus is expected to contribute positively to the farm production. Livestock provides draft power, manure fertilizer and cash income, while bigger farm size allows the opportunity to adopt improved technologies, thus increasing the farm production. Off-farm income and credit also contributes in increase of production as farmers will be able to finance the purchase of required inputs and technologies (Tesema, 2006).

Table 9.2 Hypothesized sign of independent to dependent variables

Variables	Expected sign	References
farm_method	+ve/-ve	Trewavas (2002); Meisner (2007); Badgley, et al. (2007)
HHHgender	+ve	FAO (2015)
HHHage	+ve/-ve	Guo, Wen, & Zhu (2015).
HHHedu	+ve	Tesema (2006)
HHHprimary_occu	+ve	Own elaboration
org_exp	+ve	Own elaboration
LFU	+ve	Adil, Badar, & Sher (2004); Parvin & Akteruzzaman (2012)
LSU	+ve	Tesema (2006)
farm_size	+ve	Tesema (2006)
ln_nonfarm_income	+ve	Tesema (2006)
membership	+ve	Akal (2014)
org_training	+ve	Ahmad, Jadoon, Ahmad, & Khan (2007)
VDC	+ve	Own elaboration
agrovet	+ve/-ve	Own elaboration
market	+ve/-ve	Own elaboration
credit	+ve	Tesema (2006)

Group membership is expected to increase the carrot production because such common interest groups have increased chances to access new technologies and have multiplier effect (Akal, 2014). Training related to organic farming mainly provided through such group is expected to have positive impact as well since training increases knowledge, skills and capabilities of farmers to produce in a more conducive way (Ahmad, Jadoon, Ahmad, & Khan, 2007). In the same line, farther the distance to agrovet and market, it is expected to decrease production because these institutions are the source of information and offers input which could be advantageous in improving the crop production. Labor availability can contribute in intensifying farming activities and hence increases the farm productivity and income (Adil, Badar, & Sher, 2004; Parvin & Akteruzzaman, 2012). It is expected that when farming is HHH's primary occupation, they would be more determined towards increasing production. Longer the experience of organic farming, higher the production is to be expected because such experience might have resulted in gaining various skills that could be conducive in improving the production level. Phoolbari VDC is expected to have higher production as carrot is cultivated more commercially in this VDC compared to the other two VDCs.

9.2.3 Empirical model

All the cost components are calculated for each respondent except for irrigation cost, which because of many missing data could not be incorporated. All the local measurements were first converted into a standard unit (i.e., NRs. per ha). The cost of production was then calculated using the following equation:

$$Cp = Cland + Cseed + Corg + Clitter + Cinorg + Ctillage + Cwage + Cpp \qquad (9.1)$$

where Cp = total cost; Cland = cost of land; Cseed = cost of seed; Corg = cost of organic fertilizers and pesticides; Clitter = cost of chicken litter; Cinorg = cost of conventional fertilizers and pesticides including micronutrients; Ctillage = cost of tillage (bullock and/or tractor); Cwage = cost of wage for supplied labor; and Cpp = post-production cost of processing, packaging and transportation.

Net return is calculated as:

Gross income = income accrued own consumption of carrots + income accrued from market sell of carrots (9.2)

where gross return includes income from selling the crop and those self-consumed as well.

Net return is calculated as:

$$\text{Net return} = \text{Gross income} - \text{Expenditure (Maharjan, 1997)} \quad (9.3)$$

To compare the cost components of production and net return from carrot cultivation under these two farming methods, the data was analyzed using two-sample t-test. In order to analyze the impact of farmers' socioeconomic variables on these benefits, OLS model is used.

OLS model can be expressed as:

$$y_i = \beta_0 + x_i\beta_i + \varepsilon_i \quad (9.4)$$

where i is number of observation, y_i is carrot production in kg/ha, x_i is socioeconomic variables, β_0 is coefficient of intercept, β_i is parameter to be estimated and ε_i is an error term.

The empirical specification for the model can be given by:

$$\text{Production (kg/ha)} = \beta_0 + \beta_1 \text{ HHHage} + \beta_2 \text{ HHHedu} + \beta_3 \text{ membership} + \beta_4 \text{ VDC} + \beta_5 \text{ agrovet} + \beta_6 \text{ seed} + \beta_7 \text{ organic\_inputs} + \beta_8 \text{ chicken\_litter} + \beta_9 \text{ chemical\_inputs} + \beta_{10} \text{ tillage} + \beta_{11} \text{ wage} + \varepsilon \quad (9.5)$$

As per the regression rule, diagnostic tests were carried out to check the problem of multicollinearity and heteroscedasticity in the data. The VIF gave a value of 1.87, which is below 10 (Appendix VII), indicating multicollinearity among the variables does not exist. Both Breusch-Pagan/Cook-Weisberg and White's test did not show significant P-value implying that there is no problem of linear or non-linear forms of heteroscedasticity, i.e., the variance of the error term is constant.

9.3 Results and discussion

9.3.1 Descriptive analysis

Among the cost components, only chemical inputs is such component, which can be calculated only for conventional farm. Besides that all other factors are employed in both, among which cost of land, seed, wage and post-production cost significantly differs between these two farming methods. The average land rent for conventional farm is higher than for organic farm (Table 9.3). During the field survey, the respondents did not vary land rent depending on their choice of farming method. Therefore, it is assumed that this variation could be attributed to factors other than the farming method. The study shows that the average per ha cost on seed is higher for conventional than organic carrot. The conventional farmers mostly use hybrid seeds which is much more costly than the local varieties. Organic farmers on the other hand save their local varieties or buy from their neighbors. A cooperative in Phoolbari VDC also has service of providing local varieties to its members. The most common kind of organic input employed for carrot production by farmers is manure, which is used by all farmers of both the categories (Figure 9.1). Besides that, they also relied on chicken litter, which is actually relied on more by conventional farmers (58%) compared to just 38% of organic farmers. There are only few organic farmers who have adopted bio-pesticides (7%) and Effective Microorganisms (EM) (2%), which is a combination of useful regenerative microorganisms that improves soil quality, in the carrot production. In addition to manure and chicken litter, conventional farmers though rely on various chemical fertilizers (urea, DAP and MOP), chemical pesticide (weedicide) and micronutrients (zinc, boron and vitamin) (Figure 9.2).

Table 9.3 Net-return calculation for carrot under organic and conventional farming method

Factors (NRs./ha)	Carrot								
	Organic (n=45)				Conventional (n=36)				T-test
	Mean	SD[1]	Min.	Max.	Mean	SD	Min.	Max.	
Land	12054	2478	9862	14793	13012	2402	9862	14793	**0.083 ***
Seed	14639	13729	1033	43945	20750	14879	1243	44438	**0.059 ***
Organic inputs	21387	6362	8069	35503	19167	6954	5917	38462	0.138
Chicken litter	3406	7287	0	25503	4114	4114	0	19586	0.633
Chemical inputs	0	0	0	0	2243	2569	92	9201	**-**
Tillage	17117	6947	148	29586	18497	13724	148	88757	0.559
Wage	30028	6411	14793	41091	25215	7152	14793	47337	**0.002 *****
Postproduction	10043	3272	4931	18245	12934	4665	5917	20828	**0.002 *****
Expenditure	**108673**	**22704**	**60897**	**152336**	**115932**	**24649**	**77465**	**168685**	**0.173**
Production(kg/ha)	16887	4183	9862	26627	19829	5681	11243	30178	**0.009 *****
Sold (kg/ha)	7995	8886	0	24655	15084	10343	0	29586	0.001
Sold price (NRs./kg)	11	3	8	25	10	2	5	18	**0.040 ****
Consumed (kg/ha)	8892	8045	0	23669	4750	6729	0	21133	**0.016 ****
Consumed price (NRs./kg)	10	-	10	10	10	-	10	10	-
Gross income (NRs./ha)	**178760**	**47414**	**98619**	**295858**	**187116**	**58701**	**112426**	**332840**	**0.481**
Net return (NRs./ha)	**70086**	**35259**	**22904**	**143522**	**71184**	**45658**	**22710**	**195175**	**0.903**

Source: Field survey (2013)

Note: SD[1] is Standard Deviation

*** 1%, ** 5% and * at 10% level of significance

The tillage cost on average is higher for conventional carrot production. The average wage cost confirms with the study by Khaledi et al. (2011), which suggests that organic practice is known to demand more labor. Most of the farmers pointed out that weeding takes more labor in carrot production. Since conventional growers relied on weedicide (Figure 9.2), their labor cost is significantly lower. The post-production cost includes cost incurred in the course of processing, packaging and transporting the product. The total sold amount has a direct impact on cost of packaging and transporting. Since the average sold amount is higher in conventional compared to organic production method, the average post-production cost for conventional grower is also higher. Thus, the overall cost is higher for conventional than organic growers on average and the main factors attributed to it are seed, chemical inputs and post-production cost.

Production is also higher for conventional growers (19,829 kg/ha) compared to organic growers (16,887 kg/ha). Both are higher than the average production at district level (14,000 kg/ha), regional level (central Tarai region=14,000 kg/ha and central region=13,000 kg/ha) and national level (10,600 kg/ha) as well (MoAD, 2013). Contrastingly Adhikari (2009) found a much higher production for both organic (28484 kg/ha) and conventional (29071 kg/ha) carrot growers. As for the net return, it is higher for conventional growers compared to organic growers but without any significant difference despite having a significantly higher production. This can be attributed to price at which the carrots are sold. The average price for conventional grower is NRs. 10/kg, which is significantly lower than for organic growers who sold at the average price of NRs. 11/kg. However, only 6% of total organic carrots produced by the organic farmers could be sold through a cooperative in the cities at 9% premium. The consumed amount is also included in the gross income that is calculated as an average price at which farmers sold (which in this case is at NRs. 10/kg).

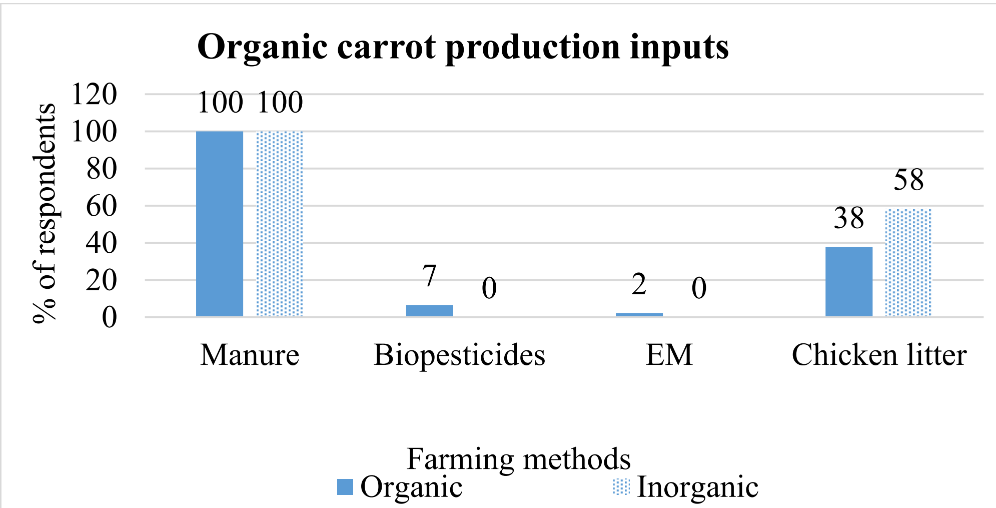

Figure 9.1 Types of organic inputs applied for carrot production under two different farming method
Source: Field survey (2013)

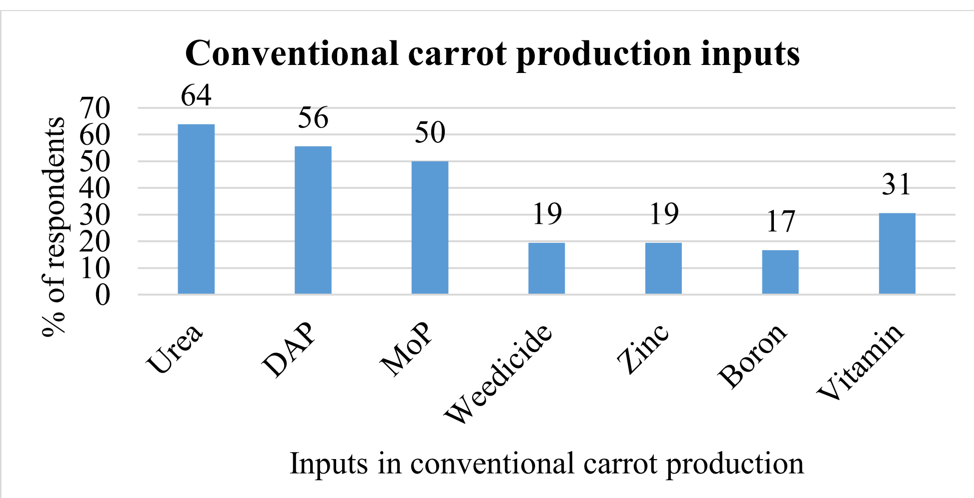

Figure 9.2 Types of conventional inputs applied under conventional carrot production
Source: Field survey (2013)

Table 9.4 Descriptive analysis of socioeconomic variables for carrot production

Dependent variable (Measurement unit)	Mean± Standard deviation / %
Production (kg/ha)	18195±5090
Independent variables	
farm_method	33%
HHHgender	91%
HHHage	50.03±11.31
HHHedu	7.62±5.40
HHHprimary_occu	56%
org_exp	3.49±7.75
LFU	4.27±1.62
LSU	2±1.30
farm_size	0.50±0.38
ln_nonfarm_income	9.26±5.36
membership	52%
org_training	1.59±2.66
VDC	54%
agrovet	1.63±1.40
market	3.30±3.60
credit	10%
seed (NRs./ha)	17355.01±14486.17
organic_inputs (NRs./ha)	14486.17±6682.33
chicken_litter (NRs./ha)	3720.88±6578.29
chemical_inputs (NRs./ha)	997.05±2036.10
tillage (NRs./ha)	17730.47±10460.6
wage (NRs./ha)	27888.75±7125.93

Source: Field survey (2013)

9.3.2 Result from ordinary least square model

The P-value for the regression model as a whole is highly significant at 1%, which supports the existence of relationship of explanatory variables with dependent variable (Table 9.5). The R^2 value suggests that about 52% of the total variation in the value of dependent variable is explained by the independent variables in this regression equation. The findings show that organic carrot production is lower by about 76 kg/ha compared to conventional carrot production, though not significant.

Table 9.5 Result from OLS model for production/ha of carrot production

Variables	Coefficient	P-value
farm_method	-76.42	0.948
HHHage	-53.73	0.220
HHHedu	-123.89	0.142
membership	**-2083.86**	**0.018****
VDC	957.20	0.293
agrovet	**-792.78**	**0.001*****
seed	**0.20**	**0.000*****
organic_inputs	-0.05	0.477
chicken_litter	0.05	0.582
chemical_inputs	0.42	0.133
tillage	0.06	0.139
wage	-0.06	0.398
constant	21384.34	0.000***

Note: *** 1%, ** 5% and * at 10% level of significance
Number of observations = 81 **Prob > F = 0.0000*****
F (11, 69) = 9.84 R-squared = 0.5164 Root MSE = 3811.3

A year increase in age will decrease production by 54 kg/ha. Farmers' ability to produce more declines with less physical capability that only intensifies with age. A year increase in formal education decreases carrot production by approximately 124 kg/ha. This could be because formal education could be seen a way to deviate one's occupation from farming to other modern sectors and that is why higher education does not really contribute in improving farm output. Membership decreases production by 2084 kg/ha, significant at 5%. This means that the formal or informal interaction that takes place among members is not inclined towards improving carrot production.

One reason could also be because crop-specific training, which is done under FFS, has not included carrot so far despite of it being one of the most commercially cultivated crops. Farmers in Phoolbari VDC can produce 957 kg/ha more carrot than farmers in other two VDCs because carrot is the most commercial non-staple crop within Phoolbari VDC and thus the production is also more intense. A kilometer more distance to agrovet decreases production by 793 kg/ha, significant at 1%, and a rupee increase in seed per hectare increases carrot production by 0.2 kg/ha, significant at 1%. Other inputs such as chicken litter, chemical inputs and tillage cost also increases carrot production; a unit increase in which will lead to increase in carrot production by 0.05, 0.42 and 0.06 kg/ha, respectively. However, a unit increase in organic inputs and wage will decrease carrot production by 0.05 and 0.06 kg/ha, respectively, which means that these inputs has been used excessively.

9.4 Conclusion

The production of carrot is significantly higher in conventional farm than organic farm. Since premium market is very limited, both types of production have to compete in the same regular market. The net return is higher in conventional carrot production but is not significantly different than organic carrot production in spite of having significantly higher production per hectare. This difference would have been much larger had organic farmers not received higher price per unit. But overall, access to premium market has not been able to make any significant contribution in farmers' income through carrot production. Thus, if access to premium market can be improved, it would also improve the income from organic carrot production. Besides training should focus on present need of a crop which is prevalent in a particular season. FFS could be an effective platform to implement such knowledge enhancing interaction. At the present scenario, seed has a highly significant positive impact on production, which suggest that assisting farmers through seed can further improve the production.

Chapter 10. Overall conclusion and recommendation

Commercialization of agriculture through conventional means is much prioritized for overall economic development of Nepal. But declining soil fertility, negative repercussions on environment and health of farmers due to use of agro-chemicals and market demand reinforced the organic movement in Nepal. Climate change and food insecurity are other important issues Nepalese agriculture sector should deal with. Organic farming is known to be the most sustainable method that claims to tackle these issues. However, sustainability needs to be assessed from three aspects (social, economic and environmental) and is very context-specific. While organic farming is known to provide better working environment for farmers by not having to come in contact with agro-chemicals and healthy living through pesticide free nutritious food, its economic viability is often questioned because of lower production and lack of premium market to compensate for this loss. Likewise in rural areas of developing countries, there is a very blur line between organic and conventional farm in a sense that both incorporates integrated farming of crops and livestock, unlike in developed countries where conventional farmers are known to have monocropping farming system and mostly relies on chemical inputs. Thus, it is necessary to assess both of these farming methods to understand the degree of variation.

This study captures economic and environmental aspects of sustainability pertaining to organic and conventional farming method. It takes the case of Chitwan district of Nepal where group conversion to organic farming exists in three adjoining village development committees, the lowest administrative unit, namely, Phoolbari, Shivanagar and Mangalpur. The respondents were selected by stratifying individual households based on their membership in a group formed for the purpose of organic farming. From the field survey, it was realized that not all farmers belonging to such group are practicing organic farming. Likewise, not all farmers not belonging to such group are practicing conventional farming. Therefore, there are both kinds of respondents within and outside such group, although most of the organic farmers are group members. The final data of 285 households is used for the analysis.

First, the study analyzes households' socioeconomic factors impacting adoption of a farming method to identify what livelihood assets encourages or deters adoption of organic farming for policy implication. In any adoption studies of agricultural innovations, livelihood assets are as important as agro-ecological variables and farmers' perception. The results show that households having higher livestock holding and receiving higher number of organic farming related training are more likely to practice organic farming. Livestock holding still plays an important role in adoption decision of organic farming because livestock manure is the main source of organic fertilizer. Training complements the technical knowledge required to practice organic farming, which is not just following the traditional way of farming but assimilating them with modern scientific knowledge as well. Thus, these two household characteristics should be emphasized for increasing the adoption rate of organic farming.

Training is mostly provided through a group that has been established for the purpose of organic farming. Such group formation creates a foundation for group conversion to organic farming but it is the training that ultimately plays crucial role in knowledge generation and information dissemination and hence higher organic farming adoption rate among farmers over a longer period of time. The reason why being a group member does not translate into practicing organic farming is because it comes with various challenges of unequal member participation in group activities and unequal entitlement by each member to the benefit received in the form of various assistances and accessibility to the premium market. One of the ways to improve such situation could be to link with the specialized shops which have started to thrive very recently in the local area that can accommodate selling the produces from more farmers. Another reason why some farmers could not convert to organic farming is inaccessibility of organically feasible varieties for crops such as rice and potato. Thus, support for full conversion can be given by distributing organically feasible varieties. Agrovets these days also sell packaged organic fertilizers and bio-pesticides which could be the reason why farther distance to it results in lesser chances of practicing organic farming, indicating the importance of commercially available organic inputs for the vitality of organic farming. Consequently, older farmers should not be prioritized for adoption of organic farming as their capacity to supply labor diminishes which is incompatible for this labor intensive farming method. Additionally, benefit from organic farming materializes only after few years of conversion, thus diminishing their enthusiasm, as they will be retired soon in the near future which leaves them with less time to enjoy the benefit.

In order to evaluate environmental implication of these farming methods, adoption of organic means of crop management practices has been analyzed. It has further been divided into two categories, soil fertility and pest management practices. Soil fertility management is usually related to dynamic properties of or those which can be controlled by humans. This study classifies five types of soil fertility management practices; mulching (conserves moisture, protects plant roots, reduces weed growth, improves soil health and fertility), compost-shed (preserves compost/manure pile from volatilization by sun or leaching by rainfall and maintains nutrient availability), bio-slurry (revitalizes soil fertility), plastic cover (maintains soil moisture and subsequently makes nutrients available) and vermicompost (improves soil fertility). For organic means of pest management, bio-pesticide is taken as it manages pests without having to rely on harmful chemical pesticides that degrades soil over time and increases pests' resistance. This study shows that even though there is an influx of modern inputs like chemical fertilizers, pesticides and micronutrients, conventional farmers still incorporate all organic means of soil fertility and pest management practices analyzed in this study. Although adoption rate for all of such practices is higher among organic farmers, indicating that organic farmers are keener on adopting such practices, especially when it comes to mulching and constructing compost-shed.

Mulching is the most traditional way of soil fertility management practice and has higher prospect to be adopted by organic farmers as they mainly follow traditional way of farming. It is also adopted by those having higher farm income as it indicates producing more crops which further provides more crop residue for mulching, and those who have taken credit which might not have direct impact but credit for higher investment in crop cultivation results in higher crop residue for mulching. However, in some instances the adoption can be hindered by lack of fund, such as in the case of compost-shed. Thus, it is advisable that fund assistance should be increased so as to increase the adoption rate of compost-shed by the majority. Tenant farmers have less resource holding which is why their probability of constructing biogas (that ultimately provides bio-slurry) decreases, as it requires higher initial investment. Similarly, those who have bigger farm size or higher farm income indicates being resource rich and thus their chances of adopting higher investment requiring practices such as compost-shed and biogas, respectively, too increases. This further proves that financial ability is the major drawback for the adoption of these sustainable practices. One of the ways to increase the adoption rate is training as it complements technical knowledge required to implement these practices. Also if such practices largely rely on locally available resources such as bio-pesticides, then even tenant farmers facing financial constraint can adopt these practices. Farmers also tend to complement most of such practices. They are practicing uncommon techniques such as plastic cover and/or vermicompost along with biogas, bio-pesticides or even with traditional ones like mulching. It indicates that any additional organic means of soil fertility or pest management practices can be introduced to those households who are already adopting one of such practices. But sometimes, these practices become substitutes because of their nature of relying on the same input such as mulching and biogas that directly or indirectly depends on crop residue. Thus, any effort to enhance such adoption rate can consider these characteristics of various practices. Hence, adoption of organic means of crop management practices is influenced in different ways by various socio-economic factors that should be regarded before any intervention.

Economic benefit is probably the most important reason for smallholder farmers to undertake any practice. Lower monetary return is a major bottleneck for large-scale adoption of organic practice. Income from organic practice may be increased through improved yield, reduced cost and access to premium market. This study analyzed crop diversification, farm income, gross farm cash income, production and net return for this matter. Crop diversification benefits environmentally (biodiversity, pest control, resource use efficiency, nutrient cycling processes, disturbances resilience, low weed infestation and nitrate leaching), socially (dietary need, employment opportunities by cultivating crops all year round) and economically (high-value crops). Crop diversity allows resource use efficiency through facilitation and complementarity between species. It maximizes profit, minimizes risk, conserves soil, improves soil fertility, controls weed, pests and diseases, and provides balanced nutrition. This study uses Shannon Diversity Index that captures both richness (number) and evenness (abundance) of species.

Organic farm in the study areas is richer in integrating more number of crop types (richness) but is poor in evenness, which resulted in having lower Shannon Diversity Index than conventional farm. Since crop evenness is better indicator of improved productivity than crop richness, it can be implied that farmers, especially organic farmers, should be made aware of this fact in order to improve their overall productivity. The socioeconomic variables that have significant positive impact on Shannon Diversity Index are education attainment, livestock holding, non-farm income, group membership and training. Clearly, educated farmers have more knowledge on benefits of having various crops and its benefits to health. Non-farm income allows farmers to intensify diversification for own household consumption rather than having to specialize for increasing income. Membership in a group formed for the purpose of organic farming and training related to organic farming can improve Shannon Diversity Index because the purpose of such group formation and training is to make farmers aware of benefits of agro-ecological principles resulting in improvement of soil fertility and hence the production. Finally farther the distance to the market will encourage farmers to have better Shannon Diversity Index because they will prioritize on being self-sufficient and avoid buying or selling in the market to save the transportation cost. Easier access to market leading to low Shannon Diversity Index suggests that market is only favorable for few selected crops, which will encourage farmers for crop specialization. Had there been market opportunities for variety of crops, it could have led to diversifying more crops which is also beneficial for overall production through various environmental services while improving income as well. Therefore, any effort to improve Shannon Diversity Index should consider these characteristics. Most importantly, effort should also be made to cultivate crops more evenly in addition to having numerous types to reap more benefit from environmental point of view, ultimately resulting in higher production.

For the farm income, which is the monetary valuation of overall farm output whether self-consumed or sold in the market; education of household head, farming as primary occupation of household head, livestock holding, farm size, farther distance to market and Shannon Diversity Index have a positive contribution. Household's decision to sell crops in the market is influenced positively by farm size, farm income, credit and knowing final price at which the consumer buys while tenant farmers, labor availability, livestock holding and group membership decreases its probability. Farm size results in increasing the probability of being involved in marketing which means that subsistence farmers might be at the losing end when it comes to earning cash income through farm activities. Thus, increasing farm size through merging and collaboration can improve market participation. Providing access to credit will also help access the means that allows farmers to be engaged in marketing crops. Market information of crops' price at which consumers buy encourages farmers not just to be involved in marketing their crops but also to subsequently increase their cash income. Thus, such information should be disseminated among farmers to improve their gross farm cash income generating capability. Tenant farmers have to pay their produce as rent and thus will have lesser amount left for marketing and increase the cash income. Unlike the previous assumption, that labor supply positively influences intensity of farm activities including being involved in marketing the crops or generating higher gross farm cash income, this study shows that labor is not any more the defining factor because it is being diverted to non-farm sector. Livestock holding takes up more space and time, leaving farmers with less area for crop cultivation and less time for marketing.

Conventional farmers earn higher gross farm cash income than organic farmers because at present, the production per hectare, commercialization rate and price per unit for almost all the crops is higher for conventional crops. In addition to that, access to premium market is very limited and has not been able to make any significant contribution to organic farmers' income. Since monetary benefit can attract farmers to divert their labor force in farming activities and specifically to boost the adoption of organic farming, making access to premium market should be very effective. Organic farmers should be linked with potential sellers not just in other cities but an effort towards market development in strategic places of the local area should be developed so that the farmers would have more control over the price and quality check of their products, which is one of the issues they are facing as a result of selling organic products through middlemen in the premium market existing in other cities.

This study compares production and net return from carrot cultivation, which according to key informant is the most commercial non-staple crop. The result finds that conventional carrot production is a high cost investment method while organic carrot production is characterized by requiring higher labor, providing lower production but needing lower investment as well. Since premium market is very limited (currently only 6% of total organic carrots produced by the organic farmers could be sold through a cooperative in the cities at 9% premium), larger amount of organic carrots produced have to compete in the same local market where conventional carrots are sold.

The net return is also higher in conventional carrot production but is not significantly different than organic carrot production. This difference would have been much larger if organic farmers had not receive higher price per unit. Thus, if access to premium market can be improved, it would also significantly improve the income from organic carrot production. Besides, training should focus on present need of a crop which is widespread in a particular season. Farmers' Field School could be an effective platform to implement such knowledge enhancing interaction. At the present scenario, seed has a highly significant positive impact on production, which suggest that assisting farmers through seed can further improve the production.

This study also uncovers that among Phoolbari, Shivanagar and Mangalpur village development committees, the latter two should be prioritized more for increasing the adoption rate of organic farming or improving farming performance in general because farmers in these two areas have lower organic farming adoption rate, Shannon Diversity Index and gross farm cash income. Overall, by assisting to strengthen the economic and environmental sustainability of a farming method will in turn support the livelihood assets of the households.

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Appendix I. Information on formal/informal groups formed for the purpose of organic farming

Features of group / VDCs	**Phoolbari**	**Shivanagar**	**Mangalpur (a)**	**Mangalpur (b)**	**Mangalpur (c)**
Group type	Cooperative	Informal	Informal	Informal	Informal
Established (year)	2005	2010	2010	2011	2011
Members:					
Male	42	9	1	1	4
Female	83	35	29	29	26
Total	125	44	30	30	30
Farmers Field School (times conducted)	13	6	2	1	1
Certified	Twice	Never	Never	Never	Never
Member saving and loan facility	Yes	Yes	Yes	Yes	Yes

Source: Field survey (2013)

Appendix II. List of types of crops under six broad categories cultivated in the study areas

English	Nepali	Scientific name
Cereals		
Rice	*Dhan*	Oryza sativa L.
Maize	*Makai*	Zea mays L.
Wheat	*Gahu*	Triticum aestivum L.
Barley	*Jau*	Hordeum vulgare L.
Oat	*Jai*	Avena sativa L.
Fingermillet	*Kodo*	Eleusine coracana (L.) Gaertn
Common Buckwheat	*Mithe phapar*	Fagopyrum esculentum Moench.
Vegetables		
Cauliflower	*Cauli / Fulgobhi*	Brassica oleracea var. botrytis L.
Cabbage	*Bandagobhi / Patgobhi*	Brassica oleracea L. var. capitata L.
Broccoli	*Brocauli*	Brassica oleracea var. italica Plenk
Kohlrabi	*Gyathgobhi*	Brassica oleracea var. gongylodes
Tomato	*Golbheda / Tamatar*	Lycopersicum esculentum Mill.
Brinjal / Eggplant	*Bhanta / Baigan*	Solanum melongena L.
Bitter Gourd	*Tito Karela*	Momordica charantia L.
Lady's Finger / Okra	*Bhidi / Ramtoriya*	Abelmoschus esculentus (L.) Moench.
Hot pepper / Chilli	*Piro khursani*	Capsicum frutescens L.
Scotch bonnet chilli	*Akabare khursani*	Capsicum chinense 'Scotch Bonnet'
Sweet pepper	*Bhide / Macha khursani*	Capsicum annuum
Common Cucumber	*Asare Kakro*	Cucumis sativus L.
Vegetable Marrow / Pumpkin	*Pharsi*	Cucurbita pepo L. var. medullosa Alef.
Squash	*Jukini pharsi*	Cucurbita L.
Bottle Gourd / Calabash	*Lauka*	Lagenaria siceraria Standl.
Sponge Gourd	*Ghiraulo*	Luffa cylindrica Roem.
Snake / Serpent gourd	*Chichindo*	Trichosanthes anguina L.
Balsam apple	*Barelo / Barela*	Momordica balsamina L.
Chayote / Christophine	*Iskus*	Sechium edule Sw.

Pointed gourd	*Parabar / Parwal*	Trichosanthes dioica Roxb.
Ash gourd	*Kubhindo*	Benincasa hispida Cogn.
Watermelon	*Tarbuja / Kharbuja*	Citrullus vulgaris Shrad.
Other Cucurbitaceae	***Anya phal tarakari***	
Garden Pea	*Matarkosa*	Pisium sativum L.
Field Bean	*Simi*	Phaseolus sp.
Cowpea	*Bodi*	Vigna sinensis Savi.
Fava Bean / Broad Bean	*Bakula*	Vicia faba L.
Soybean	*Bhatmas / Bhatmaskosa*	Glycine max (L.) Merr.
Other Leguminosae	***Anya kose tarakari***	
Mustard Green / Leaf Mustard	*Rayo ko saag*	Brassica juncea (L.) Czerniak
Garden Cress	*Chamsur ko saag*	Lepidium sativum L.
Spinach	*Palungo ko saag*	Spinacia oleracea L.
Mustard Green	*Tori ko saag*	Brassica juncea
Buckwheat Greens	*Fapar ko saag*	Fagopyrum esculentum
Fenu-greek leaves	*Methi ko saag*	Trigonella foenum-graecum L.
Green garlic	*Hariyo lasun*	Allium sativum L.
Onion green	*Hariyo pyaj*	Allium cepa L.
Pumpkin shoot	*Farsi ko munta*	Cucurbita moschata
Colocasia leaf	*Karkalo/gaava (Pidhaalu)*	Colocasia esculenta
Other leafy vegetables	***Aanya saag***	
Radish	*Mula*	Raphanus sativus L.
Turnip	*Salgam/Gantemula*	Brassica rapa L.
Carrot	*Gajar*	Daucus carota L. var. sativa DC.
Onion	*Pyaj*	Allium cepa L.
Garlic	*lasun*	Allium sativum L.
Other root vegetables	***Anya jare tarkari***	

Cassava	*Tarul*	Manihot esculenta
Colocasia / Taro	*Pidalu*	Colocasia esculenta
Elephant foot yam	*Ole*	Amorphophallus paeoniifolius
Sweet potato	*Sakhar Khanda*	Ipomoea batatas Lam.
Other tuber vegetables	***Anya kandamul***	
Asparagus	*Kurilo*	Asparagus officinalis L.
Potato	*Aalu*	Solanum tuberosum L.
	Jhute ghiraula	
Luffa Gourd	*Pate ghiraula*	Luffa acutangula (L.) Roxb.
Winged Bean	*Pate Simi*	Psophocarpus tetragonolobus (L.) DC.
Velvet Bean	*Kause Simi*	Mucuna pruriens
Chinese Leek	*Chinese saag*	Allium tuberosum
Green Amaranth	*Latte ko saag*	Amaranthus viridis L.
	Pitpite	
Spices		
Coriander	*Dhaniya*	Coriandrum sativum L.
Turmeric	*Besar*	Curcuma domestica Valet.
Ginger	*Aduwa*	Zingiber officinale Rosc.
Aniseed	*Souf*	Pimpinella anisum L.
Bay Leaf	*Tejpatta*	Laurus nobilis L.
Betel Nut / Areca Nut	*Supari*	Areca catechu L.
	Marathi	
Field Mint	*Patena / Pudina*	Mentha arvensis L.
Jimbu	*Jimbu*	Allium hypsistum
Fenugreek	*Methi*	Trigonella foenum-graecum L.
Chinese Parsley	*Chinese dhaniya*	Coriandrum sativum L.
	Rose beri	
Pulses		
Kidney Bean	*Rajma*	Phaseolus vulgaris L.
Black Gram	*Kalo mas*	Vigna mungo (L.) Hepper

Mung Bean	*Mungi mas*	Vigna radiata (L.) R. Wilczek
Red Gram / Pigeon Pea	*Rahar*	Cajanus cajan Millsp.
Red Lentil	*Musuro*	Lens culinaris Medikus
Chickpea	*Chana*	Cicer arietinum L.
Garden Pea	*Kerau*	Pisum sativum L.
Field Pea	*Sano kerau*	Pisum sativum L. var. arvense (L.) Poiret
Cowpea	*Bodi*	Vigna unguiculata (L.) Walp.
Other common field beans		
Grass Pea / Indian Pea	*Khesari*	Lathyrus sativus L.
Rice Bean	*Masyang*	Phaseolus calcaratus Roxb.
Soybean	*Bhatamas*	Glycine max (L.) Merr.
Broad Bean	*Bakulo simi*	Vicia faba L.
Oil seeds		
Indian Rape / Mustard	*Tori*	Brassica campestris var. toria Duth. & Full.
Mahua Seed	*Tora*	Madhuca longifolia
Indian colza	*Sarsyun / Sarson*	Rayo
Sunflower	*Suryamukhi*	Helianthus annuus L.
Perilla	*Silum*	Perilla frutescens Britt.
Fruits		
Guava	*Amba*	Psidium guajava L.
Grape	*Angur*	Vitis vinifera L.
	Amara	
Pomegranate	*Anar*	Punica granatum L.
Mango	*Aap*	Mangifera indica L.
Peach	*Aaru*	Prunus persica (L.) Batsch
Gooseberry	*Amala*	Ribes uva-crispa (L.)
	Lahere aap	
Sugarcane	*Ukhu*	Saccharum officinarum L.

Avacado	*Avocado*	Persea americana
Pineapple	*Bhui katahar*	Ananas comosus (L.) Merr.
Jackfruit	*Rukh katahar*	Artocarpus heterophyllus Lamk.
Lemon	*Kagati*	Citrus limon Burm.
Jamun	*Jamun*	Syzygium cumini L.
Black Mulberry	*Kimbu*	Morus alba L.
Banana	*Kera*	Musa x paradisiaca L.
Plum Rose / Water Apple	*Gulab jamun*	Syzygium jambos
Papaya	*Mewa*	Carica papaya L.
Litchi	*Licchi*	Nephelium litchi Camp.
Kumquat	*Muntala*	Citrus japonica
Indian Plum	*Bayer*	Oemleria cerasiformis
Coconut	*Nariwal*	Cocos nucifera L.
Common Pear	*Naspati*	Pyrus communis L.
Bayberry	*Kafal*	Myrica L.
Pummelo	*Bhogate*	Citrus grandis Osbeck

Appendix III. Testing for multicollinearity and heteroscedasticity (Chapter 5: Livelihood assets impacting adoption of a farming method)

Testing for multicollinearity:

Variation inflation factor (VIF)

Variable	VIF	1/VIF
cash_incom~a	2.88	0.346649
commercial~n	2.63	0.380388
ln_farm_in~e	1.92	0.519876
orgtraining	1.87	0.535305
_Imembersh~1	1.72	0.580456
_Ihhprima~1	1.71	0.583583
hhhedu	1.65	0.605948
hhhage	1.46	0.686979
farm_sizeha	1.45	0.687625
ln_nonfarm~e	1.44	0.696853
shdi	1.41	0.708558
_Ivdc_1	1.41	0.710405
_Ifinal_pr~1	1.34	0.746380
agrovet	1.25	0.797428
org_exp	1.25	0.797494
market	1.25	0.798240
lsu	1.22	0.821288
lfu	1.20	0.830398
_Icredit_1	1.19	0.842361
_Ihhgende~1	1.15	0.865802
_Irent_1	1.13	0.881438
Mean VIF	1.55	

Correlation matrix

	farm_s~m	hhhgen~r	hhhage	hhhedu	hhhpri~u	rent	org_exp	lfu	lsu	farm_s~a	ln_far~e	ln_non~e	member~p	orgtra~g
farm_system	1.0000													
hhhgender	-0.0458	1.0000												
hhhage	-0.0836	-0.1288	1.0000											
hhhedu	0.0802	0.2485	-0.3704	1.0000										
hhhprimary~u	-0.0360	-0.1502	0.3411	-0.4578	1.0000									
rent	0.0096	0.0290	-0.0823	-0.1285	0.0155	1.0000								
org_exp	0.6355	0.0046	0.0375	0.0716	0.0156	-0.0677	1.0000							
lfu	-0.0029	0.0070	0.2104	-0.1324	0.2050	0.0338	0.0349	1.0000						
lsu	0.0731	0.0683	0.0381	0.0989	0.0136	-0.0371	0.0380	0.1061	1.0000					
farm_sizeha	-0.0284	0.0572	0.2074	0.0053	0.1398	0.1174	-0.0028	0.2306	0.1431	1.0000				
ln_farm_in~e	-0.0272	0.0858	0.1518	0.0577	0.2380	0.0483	0.0385	0.1422	0.3423	0.4235	1.0000			
ln_nonfarm~e	-0.0057	-0.0765	-0.0721	0.1248	-0.3822	-0.0181	-0.0443	0.0214	-0.0541	-0.2299	-0.2419	1.0000		
membership	0.3903	-0.0027	-0.1226	0.0824	-0.1092	-0.0325	0.2252	-0.0482	-0.0062	-0.1080	-0.0822	0.0649	1.0000	
orgtraining	0.4724	-0.0133	-0.0436	0.1193	0.0102	-0.0384	0.3939	-0.0281	-0.0134	0.0063	0.0969	-0.1927	0.5547	1.0000
vdc	0.2405	-0.1191	0.0706	0.1134	0.0123	-0.1057	0.2315	-0.0680	0.1358	0.1272	0.1103	-0.0679	0.1576	0.1978
agrovet	-0.0587	0.0542	0.0238	0.0780	-0.0191	-0.0458	0.0904	-0.0007	0.1935	0.0410	0.1291	0.0147	-0.1742	-0.0550
market	0.0473	0.0526	-0.0522	0.0656	-0.0082	-0.0302	0.0735	-0.0041	0.1345	0.0012	0.2063	-0.1189	-0.0962	0.0513
credit	0.0097	0.0519	-0.0127	-0.0744	0.1082	0.1233	-0.0123	0.0024	0.0458	0.0385	0.1380	-0.1095	-0.0429	0.0489
final_price	0.0165	0.1016	-0.1573	0.0883	0.1013	0.0583	0.0387	0.0671	0.1312	0.0858	0.2166	-0.1390	-0.1043	-0.0088
commercial~n	-0.0532	0.0560	-0.0722	0.0696	0.1675	-0.0423	0.0163	-0.0416	0.0842	0.2364	0.4077	-0.2295	-0.1351	0.0265
ln_cash_in~a	-0.0599	-0.0169	0.0572	0.0743	0.1669	-0.1233	0.0228	-0.0217	0.0599	0.2551	0.4101	-0.1769	-0.1501	0.0021
cash_incom~a	-0.1224	0.0335	-0.0059	0.0859	0.1330	-0.0884	-0.0143	-0.0599	0.1034	0.2921	0.4732	-0.1763	-0.1560	0.0050
shdi	0.0556	0.0507	-0.0339	0.2781	-0.0881	-0.1056	0.1298	0.0226	0.1952	0.0180	0.2597	0.0791	0.2131	0.2529
_Ihhhgende~1	-0.0458	1.0000	-0.1288	0.2485	-0.1502	0.0290	0.0046	0.0070	0.0683	0.0572	0.0858	-0.0765	-0.0027	-0.0133
_Ihhhprima~1	-0.0360	-0.1502	0.3411	-0.4578	1.0000	0.0155	0.0156	0.2050	0.0136	0.1398	0.2380	-0.3822	-0.1092	0.0102
_Imembersh~1	0.3903	-0.0027	-0.1226	0.0824	-0.1092	-0.0325	0.2252	-0.0482	-0.0062	-0.1080	-0.0822	0.0649	1.0000	0.5547
_Ivdc_1	0.2405	-0.1191	0.0706	0.1134	0.0123	-0.1057	0.2315	-0.0680	0.1358	0.1272	0.1103	-0.0679	0.1576	0.1978
_Icredit_1	0.0097	0.0519	-0.0127	-0.0744	0.1082	0.1233	-0.0123	0.0024	0.0458	0.0385	0.1380	-0.1095	-0.0429	0.0489
_Ifinal_pr~1	0.0165	0.1016	-0.1573	0.0883	0.1013	0.0583	0.0387	0.0671	0.1312	0.0858	0.2166	-0.1390	-0.1043	-0.0088
_Irent_1	0.0096	0.0290	-0.0823	-0.1285	0.0155	1.0000	-0.0677	0.0338	-0.0371	0.1174	0.0483	-0.0181	-0.0325	-0.0384

	vdc	agrovet	market	credit	final_~e	commer~n	ln_cas~a	cash_i~a	shdi	_Ihhhg~1	_Ihhhp~1	_Imemb~1	_Ivdc_1	_Icred~1
vdc	1.0000													
agrovet	0.2328	1.0000												
market	0.2261	0.1378	1.0000											
credit	0.0633	0.2544	0.1403	1.0000										
final_price	0.1721	0.1380	0.2981	0.2200	1.0000									
commercial~n	0.1190	0.0868	0.2041	0.1450	0.3041	1.0000								
ln_cash_in~a	0.1579	0.1119	0.1109	0.1370	0.2718	0.6451	1.0000							
cash_incom~a	0.1549	0.1087	0.1448	0.1669	0.3071	0.7683	0.6750	1.0000						
shdi	0.3112	0.1452	0.1871	-0.0034	0.0965	0.0530	0.1226	0.0832	1.0000					
_Ihhhgende~1	-0.1191	0.0542	0.0526	0.0519	0.1016	0.0560	-0.0169	0.0335	0.0507	1.0000				
_Ihhhprima~1	0.0123	-0.0191	-0.0082	0.1082	0.1013	0.1675	0.1669	0.1330	-0.0881	-0.1502	1.0000			
_Imembersh~1	0.1576	-0.1742	-0.0962	-0.0429	-0.1043	-0.1351	-0.1501	-0.1560	0.2131	-0.0027	-0.1092	1.0000		
_Ivdc_1	1.0000	0.2328	0.2261	0.0633	0.1721	0.1190	0.1579	0.1549	0.3112	-0.1191	0.0123	0.1576	1.0000	
_Icredit_1	0.0633	0.2544	0.1403	1.0000	0.2200	0.1450	0.1370	0.1669	-0.0034	0.0519	0.1082	-0.0429	0.0633	1.0000
_Ifinal_pr~1	0.1721	0.1380	0.2981	0.2200	1.0000	0.3041	0.2718	0.3071	0.0965	0.1016	0.1013	-0.1043	0.1721	0.2200
_Irent_1	-0.1057	-0.0458	-0.0302	0.1233	0.0583	-0.0423	-0.1233	-0.0884	-0.1056	0.0290	0.0155	-0.0325	-0.1057	0.1233

	_Ifina~1	_Irent_1
_Ifinal_pr~1	1.0000	
_Irent_1	0.0583	1.0000

Note: Correlation matrix above is applicable from Chapter 5 through Chapter 8, as all the models take same variables.

Testing for Heteroscedasticity:

Breusch-Pagan/Cook-Weisberg test

Breusch-Pagan / Cook-Weisberg test for heteroscedasticity

Ho	:	Constant variance
Variables	:	fitted values of farm_method
$chi^2(1)$	=	64.29
Prob > chi^2	=	0.0000

White's test

White's test for Ho	:	homoskedasticity
against Ha	:	unrestricted heteroscedasticity
$chi^2(245)$	=	261.92
Prob > chi^2	=	0.2185

Cameron & Trivedi's decomposition of IM-test

Source	chi^2	df	p
Heteroscedasticity	261.92	245	0.2185
Skewness	117.71	21	0.0000
Kurtosis	0.31	1	0.5782
Total	379.94	267	0.0000

Appendix IV. Testing for multicollinearity and heteroscedasticity (Chapter 6: Nature of crop diversification)

Testing for multicollinearity:

Variation inflation factor (VIF)

Variable	VIF	1/VIF
_Ifarm_sys~1	2.06	0.484726
orgtraining	1.88	0.532717
org_exp	1.84	0.544287
_Imembersh~1	1.71	0.586472
_Ihhhprima~1	1.60	0.623141
hhhedu	1.56	0.639148
ln_nonfarm~e	1.40	0.714148
hhhage	1.37	0.728564
_Ivdc_1	1.33	0.753024
agrovet	1.27	0.787246
farm_sizeha	1.25	0.802185
lfu	1.16	0.859600
_Ihhhgende~1	1.15	0.869942
_Icredit_1	1.14	0.873636
market	1.14	0.877111
lsu	1.12	0.895541
_Irent_1	1.10	0.909197
Mean VIF	1.42	

Testing for Heteroscedasticity:

Breusch-Pagan/Cook-Weisberg test

Breusch-Pagan / Cook-Weisberg test for heteroscedasticity

Ho	:	Constant variance
Variables	:	fitted values of shdi
$chi^2(1)$	=	4.40
Prob > chi^2	=	0.0359

White's test

White's test for Ho	:	homoskedasticity
against Ha	:	unrestricted heteroscedasticity
$chi^2(162)$	=	166.80
Prob > chi^2	=	0.3818

Cameron & Trivedi's decomposition of IM-test

Source	chi^2	df	p
Heteroscedasticity	166.80	162	0.3818
Skewness	18.80	17	0.3403
Kurtosis	1.41	1	0.2352
Total	187.00	180	0.3448

Appendix V. Testing for multicollinearity and heteroscedasticity (Chapter 7: Organic means of crop management practices)

Testing for multicollinearity (mulching):

Variation inflation factor (VIF)

Variable	VIF	1/VIF
_Ifarm_sys~1	2.14	0.466810
orgtraining	1.95	0.511588
org_exp	1.85	0.541218
ln_farm_in~e	1.81	0.552573
_Imembersh~1	1.75	0.571978
_Ihhhprima~1	1.70	0.589506
hhhedu	1.65	0.606962
shdi	1.45	0.689534
ln_nonfarm~e	1.44	0.695746
farm_sizeha	1.44	0.695791
hhhage	1.43	0.701417
_Ivdc_1	1.41	0.710375
commercial~n	1.37	0.727949
agrovet	1.27	0.784393
lsu	1.24	0.809715
market	1.20	0.833065
lfu	1.18	0.849459
_Icredit_1	1.16	0.862149
_Ihhhgende~1	1.15	0.868447
_Irent_1	1.11	0.897353
Mean VIF	1.48	

Testing for Heteroscedasticity:

Breusch-Pagan/Cook-Weisberg test

Breusch-Pagan / Cook-Weisberg test for heteroscedasticity

Ho	:	Constant variance
Variables	:	fitted values of mulch
$chi^2(1)$	=	14.97
Prob > chi^2	=	0.0001

White's test

White's test for Ho	:	homoskedasticity
against Ha	:	unrestricted heteroscedasticity
$chi^2(222)$	=	246.40
Prob > chi^2	=	0.1252

Cameron & Trivedi's decomposition of IM-test

Source	chi^2	df	p
Heteroscedasticity	246.40	222	0.1252
Skewness	91.62	20	0.0000
Kurtosis	30.46	1	0.0000
Total	368.48	243	0.0000

Testing for multicollinearity (compost-shed):

Variation inflation factor (VIF)

Variable	VIF	1/VIF
_Ifarm_sys~1	2.14	0.466810
orgtraining	1.95	0.511588
org_exp	1.85	0.541218
ln_farm_in~e	1.81	0.552573
_Imembersh~1	1.75	0.571978
_Ihhhprima~1	1.70	0.589506
hhhedu	1.65	0.606962
shdi	1.45	0.689534
ln_nonfarm~e	1.44	0.695746
farm_sizeha	1.44	0.695791
hhhage	1.43	0.701417
_Ivdc_1	1.41	0.710375
commercial~n	1.37	0.727949
agrovet	1.27	0.784393
lsu	1.24	0.809715
market	1.20	0.833065
lfu	1.18	0.849459
_Icredit_1	1.16	0.862149
_Ihhhgende~1	1.15	0.868447
_Irent_1	1.11	0.897353
Mean VIF	1.48	

Testing for Heteroscedasticity:

Breusch-Pagan/Cook-Weisberg test

Breusch-Pagan / Cook-Weisberg test for heteroscedasticity

Ho	:	Constant variance
Variables	:	fitted values of compost
$chi^2(1)$	=	24.20
Prob > chi^2	=	0.0000

White's test

White's test for Ho	:	homoskedasticity
against Ha	:	unrestricted heteroscedasticity
$chi^2(222)$	=	231.36
Prob > chi^2	=	0.3193

Testing for multicollinearity (bio-slurry):

Variation inflation factor (VIF)

Variable	VIF	1/VIF
_Ifarm_sys~1	2.14	0.466810
orgtraining	1.95	0.511588
org_exp	1.85	0.541218
ln_farm_in~e	1.81	0.552573
_Imembersh~1	1.75	0.571978
_Ihhhprima~1	1.70	0.589506
hhhedu	1.65	0.606962
shdi	1.45	0.689534
ln_nonfarm~e	1.44	0.695746
farm_sizeha	1.44	0.695791
hhhage	1.43	0.701417
_Ivdc_1	1.41	0.710375
commercial~n	1.37	0.727949
agrovet	1.27	0.784393
lsu	1.24	0.809715
market	1.20	0.833065
lfu	1.18	0.849459
_Icredit_1	1.16	0.862149
_Ihhhgende~1	1.15	0.868447
_Irent_1	1.11	0.897353
Mean VIF	1.48	

Testing for Heteroscedasticity:

Breusch-Pagan/Cook-Weisberg test

Breusch-Pagan / Cook-Weisberg test for heteroscedasticity

Ho	:	Constant variance
Variables	:	fitted values of biogas
$chi^2(1)$	=	2.83
Prob > chi^2	=	0.0922

White's test

White's test for Ho	:	homoskedasticity
against Ha	:	unrestricted heteroscedasticity
$chi^2(222)$	=	240.17
Prob > chi^2	=	0.1919

Cameron & Trivedi's decomposition of IM-test

Source	chi^2	df	p
Heteroscedasticity	240.17	222	0.1919
Skewness	48.41	20	0.0004
Kurtosis	38.97	1	0.0000
Total	327.55	243	0.0002

Testing for multicollinearity (bio-pesticide):

Variation inflation factor (VIF)

Variable	VIF	1/VIF
_Ifarm_sys~1	2.14	0.466810
orgtraining	1.95	0.511588
org_exp	1.85	0.541218
ln_farm_in~e	1.81	0.552573
_Imembersh~1	1.75	0.571978
_Ihhhprima~1	1.70	0.589506
hhhedu	1.65	0.606962
shdi	1.45	0.689534
ln_nonfarm~e	1.44	0.695746
farm_sizeha	1.44	0.695791
hhhage	1.43	0.701417
_Ivdc_1	1.41	0.710375
commercial~n	1.37	0.727949
agrovet	1.27	0.784393
lsu	1.24	0.809715
market	1.20	0.833065
lfu	1.18	0.849459
_Icredit_1	1.16	0.862149
_Ihhhgende~1	1.15	0.868447
_Irent_1	1.11	0.897353
Mean VIF	1.48	

Testing for Heteroscedasticity:

Breusch-Pagan/Cook-Weisberg test

Breusch-Pagan / Cook-Weisberg test for heteroscedasticity

Ho	:	Constant variance
Variables	:	fitted values of biopesticide
$chi^2(1)$	=	47.77
Prob > chi^2	=	0.0000

White's test

White's test for Ho	:	homoskedasticity
against Ha	:	unrestricted heteroscedasticity
$chi^2(222)$	=	221.35
Prob > chi^2	=	0.4997

Cameron & Trivedi's decomposition of IM-test

Source	chi^2	df	p
Heteroscedasticity	221.35	222	0.4997
Skewness	90.24	20	0.0000
Kurtosis	16.99	1	0.0000
Total	328.57	243	0.0002

Testing for multicollinearity (others):

Variation inflation factor (VIF)

Variable	VIF	1/VIF
_Ifarm_sys~1	2.14	0.466810
orgtraining	1.95	0.511588
org_exp	1.85	0.541218
ln_farm_in~e	1.81	0.552573
_Imembersh~1	1.75	0.571978
_Ihhhprima~1	1.70	0.589506
hhhedu	1.65	0.606962
shdi	1.45	0.689534
ln_nonfarm~e	1.44	0.695746
farm_sizeha	1.44	0.695791
hhhage	1.43	0.701417
_Ivdc_1	1.41	0.710375
commercial~n	1.37	0.727949
agrovet	1.27	0.784393
lsu	1.24	0.809715
market	1.20	0.833065
lfu	1.18	0.849459
_Icredit_1	1.16	0.862149
_Ihhhgende~1	1.15	0.868447
_Irent_1	1.11	0.897353
Mean VIF	1.48	

Testing for Heteroscedasticity:

Breusch-Pagan/Cook-Weisberg test

Breusch-Pagan / Cook-Weisberg test for heteroscedasticity

Ho	:	Constant variance
Variables	:	fitted values of others
$chi^2(1)$	=	31.01
Prob > chi^2	=	0.0000

White's test

White's test for Ho	:	homoskedasticity
against Ha	:	unrestricted heteroscedasticity
$chi^2(222)$	=	216.20
Prob > chi^2	=	0.5972

Cameron & Trivedi's decomposition of IM-test

Source	chi^2	df	p
Heteroscedasticity	216.20	222	0.5972
Skewness	45.02	20	0.0011
Kurtosis	39.26	1	0.0000
Total	300.48	243	0.0070

Appendix VI. Testing for multicollinearity and heteroscedasticity (Chapter 8: Farm income and gross farm cash income)

Testing for multicollinearity:

Variation inflation factor (VIF) (farm income)

Variable	VIF	1/VIF
_Ifarm_sys~1	2.13	0.469745
orgtraining	1.94	0.514640
org_exp	1.85	0.541943
_Imembersh~1	1.74	0.575068
_Ihhhprima~1	1.64	0.610341
hhhedu	1.63	0.611721
ln_nonfarm~e	1.43	0.699239
hhhage	1.43	0.699264
_Ivdc_1	1.41	0.707197
shdi	1.38	0.725360
agrovet	1.27	0.784637
final_price	1.27	0.785335
farm_sizeha	1.25	0.800964
market	1.22	0.822264
lfu	1.17	0.851380
_Icredit_1	1.17	0.851944
_Ihhhgende~1	1.16	0.865468
lsu	1.15	0.872639
_Irent_1	1.10	0.906626
Mean VIF	1.44	

Testing for Heteroscedasticity:

Breusch-Pagan/Cook-Weisberg test

Breusch-Pagan / Cook-Weisberg test for heteroscedasticity

Ho	:	Constant variance
Variables	:	fitted values of ln_farm_income
$chi^2(1)$	=	8.32
Prob > chi^2	=	0.0039

White's test

White's test for Ho	:	homoskedasticity
against Ha	:	unrestricted heteroscedasticity
$chi^2(200)$	=	198.97
Prob > chi^2	=	0.5072

Cameron & Trivedi's decomposition of IM-test

Source	chi^2	df	p
Heteroscedasticity	198.97	200	0.5072
Skewness	28.85	19	0.0684
Kurtosis	0.92	1	0.3382
Total	228.74	220	0.3289

Testing for multicollinearity:

Variation inflation factor (VIF) (bicash income)

Variable	VIF	1/VIF
_Ifarm_sys~1	2.13	0.468557
orgtraining	1.96	0.511350
org_exp	1.85	0.541787
_Imember_c~1	1.74	0.573148
_Ihhhprima~1	1.70	0.589550
ln_farm_in~e	1.66	0.602885
hhhedu	1.65	0.606468
shdi	1.44	0.693136
hhhage	1.44	0.694776
ln_nonfarm~e	1.44	0.696788
_Ivdc_1	1.43	0.701717
farm_sizeha	1.42	0.704299
final_price	1.28	0.779473
agrovet	1.27	0.784544
mkt_distance	1.24	0.809261
lsu	1.23	0.811620
_Icredit_1	1.18	0.848205
lfu	1.17	0.851506
_Ihhhgende~1	1.16	0.864798
_Irent_1	1.11	0.904681
Mean VIF	1.47	

Testing for Heteroscedasticity:

Breusch-Pagan/Cook-Weisberg test

Breusch-Pagan / Cook-Weisberg test for heteroscedasticity

Ho	:	Constant variance
Variables	:	fitted values of bicash_incomeha
$chi^2(1)$	=	28.90
Prob > chi^2	=	0.0000

White's test

White's test for Ho	:	homoskedasticity
against Ha	:	unrestricted heteroscedasticity
$chi^2(221)$	=	231.29
Prob > chi^2	=	0.3037

Cameron & Trivedi's decomposition of IM-test

Source	chi^2	df	p
Heteroscedasticity	231.29	221	0.3037
Skewness	88.36	20	0.0000
Kurtosis	0.00	1	0.9537
Total	319.65	242	0.0006

Testing for multicollinearity:

Variation inflation factor (VIF) (gross farm cash income)

Variable	VIF	1/VIF
_Ifarm_sys~1	2.22	0.449833
orgtraining	2.09	0.479131
org_exp	1.91	0.524751
_Ihhprima~1	1.87	0.536157
hhhedu	1.81	0.552162
_Imember_c~1	1.77	0.564340
ln_farm_in~e	1.56	0.640896
ln_nonfarm~e	1.50	0.668824
shdi	1.45	0.689588
hhhage	1.44	0.692329
farm_sizeha	1.38	0.722493
_Ivdc_1	1.36	0.736273
final_price	1.29	0.774356
mkt_distance	1.24	0.804070
lfu	1.22	0.819617
lsu	1.20	0.830753
_Icredit_1	1.20	0.835029
agrovet	1.19	0.839343
_Ihhgende~1	1.15	0.867927
_Irent_1	1.12	0.889086
Mean VIF	1.50	

Testing for Heteroscedasticity:

Breusch-Pagan/Cook-Weisberg test

Breusch-Pagan / Cook-Weisberg test for heteroscedasticity

Ho	:	Constant variance
Variables	:	fitted values of cash_incomeha
$chi^2(1)$	=	7.51
Prob > chi^2	=	0.0062

White's test

White's test for Ho	:	homoskedasticity
against Ha	:	unrestricted heteroscedasticity
$chi^2(220)$	=	224.29
Prob > chi^2	=	0.4072

Cameron & Trivedi's decomposition of IM-test

Source	chi^2	df	p
Heteroscedasticity	224.29	220	0.4072
Skewness	38.56	20	0.0076
Kurtosis	-2544.60	1	1.0000
Total	-2281.75	241	1.0000

Endogeneity test between farm income and farm size

Linear regression	
	Number of obs = 225
	F(8, 216) = 40.53
	Prob > F = 0.0000
	R-squared = 0.5474
	Root MSE = 38496

cash_incomeha	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf. Interval]	
farm_method	-13250.41	5609.07	-2.36	0.019	-24305.93	-2194.892
rent	-12393.11	5881.205	-2.11	0.036	-23985.01	-801.2079
lfu	-2458.525	1311.268	-1.87	0.062	-5043.044	125.9949
ln_farm_income	17932.55	3873.453	4.63	0.000	10297.95	25567.16
vdc	9286.908	5629.945	1.65	0.100	-1809.755	20383.57
mkt_distance	-1340.036	841.63	-1.59	0.113	-2998.896	318.8226
final_price	11412.14	6625.729	1.72	0.086	-1647.223	24471.5
commercialization	49290.68	5213.157	9.46	0.000	39015.51	59565.85
_cons	-170856.7	41536.19	-4.11	0.000	-252724.8	-88988.52

Linear regression	
	Number of obs = 225
	F(8, 216) = 10.99
	Prob > F = 0.0000
	R-squared = 0.2626
	Root MSE = .69458

ln_farm_income	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf. Interval]	
farm_sizeha	.6101529	.1176542	5.19	0.000	.3782557	.8420501
farm_method	-.0903359	.103788	-0.87	0.385	-.2949028	.1142311
rent	.0836891	.1206147	0.69	0.489	-.1540434	.3214217
lfu	.0306659	.0249696	1.23	0.221	-.0185494	.0798812

vdc	-.0280474	.0953961	-0.29	0.769	-.2160738	.159979
mkt_distance	.0364659	.0141949	2.57	0.011	.0084876	.0644441
final_price	.0856068	.1254124	0.68	0.496	-.1615819	.3327956
commercialization	.2925614	.1247891	2.34	0.020	.0466011	.5385217
_cons	11.14005	.1511051	73.72	0.000	10.84222	11.43788

(1) farm_sizeha = 0

F(1, 216) = 26.89

Prob > F = 0.0000

Linear regression

Number of obs = 225
F(9, 215) = 37.63
Prob > F = 0.0000
R-squared = 0.5513
Root MSE = 38421

cash_incomeha	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
farm_method	-11609.61	5581.731	-2.08	0.039	-22611.53	-607.6904
rent	-14941.88	6562.619	-2.28	0.024	-27877.19	-2006.575
lfu	-3417.446	1615.415	-2.12	0.036	-6601.525	-233.3674
ln_farm_income	31572.48	15529.48	2.03	0.043	962.9441	62182.01
vdc	8624.357	5574.817	1.55	0.123	-2363.936	19612.65
mkt_distance	-1754.709	988.5593	-1.78	0.077	-3703.218	193.8002
final_price	10524.52	6416.16	1.64	0.102	-2122.114	23171.15
commercialization	44360.17	7777.452	5.70	0.000	29030.35	59689.99
resid	-15345.81	16299.16	-0.94	0.348	-47472.42	16780.8
_cons	-323838.1	173697.8	-1.86	0.064	-666206.8	18530.51

Appendix VII. Testing for multicollinearity and heteroscedasticity (Chapter 9: Production and net return from carrot production)

Testing for multicollinearity:

Variation inflation factor (VIF)

Variable	VIF	1/VIF
org_exp	3.12	0.320417
orgtraining	3.12	0.320637
_Ifarm_sys~1	2.73	0.366176
_Ihhhprima~1	2.39	0.417921
_Imembersh~1	2.14	0.467389
hhhedu	1.95	0.513812
hhhage	1.82	0.549268
ln_nonfarm~e	1.81	0.553268
_Ivdc_1	1.77	0.565721
wageha	1.75	0.573025
agrovet	1.72	0.580455
seed_priceha	1.71	0.584890
lfu	1.70	0.589754
lsu	1.68	0.596310
chemicalpr~a	1.67	0.599247
farm_sizeha	1.66	0.602942
_Ihhhgende~1	1.57	0.636745
totalmanur~a	1.54	0.650251
tillage_co~a	1.46	0.683788
market	1.31	0.765333
totalchick~a	1.29	0.776061
_Icredit_1	1.26	0.796283
Mean VIF	1.87	

Testing for Heteroscedasticity:

Breusch-Pagan/Cook-Weisberg test

Breusch-Pagan / Cook-Weisberg test for heteroscedasticity

Ho	:	Constant variance
Variables	:	fitted values of productionha
$chi^2(1)$	=	0.77
Prob > chi^2	=	0.3807

White's test

White's test for Ho	:	homoskedasticity
against Ha	:	unrestricted heteroscedasticity
$chi^2(80)$	=	81.00
Prob > chi^2	=	0.4477

Cameron & Trivedi's decomposition of IM-test

Source	chi^2	df	p
Heteroscedasticity	81.00	80	0.4477
Skewness	18.75	22	0.6604
Kurtosis	2.69	1	0.1010
Total	102.44	103	0.4969