DETERMINANTS IN AGRICULTURE TECHNOLOGY ADOPTION AND ROLE OF EDUCATION

(A Case of Rice Production in Chitwan and Kavre Districts of Nepal)

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ABSTRACT

Proper understanding of the agricultural technology adoption process is central to development of agriculture sector. The main objective of the study was to identify the major determining variables of technology adoption and their level of contribution to embodied (improved rice varieties) and disembodied (integrated pest management) agricultural technologies in a smallholding farming context. A conceptual framework was developed based on the utility maximization theory, the theory of planned behavior, and the human capital theory to understand and explain the adoption process. Based on the post-positivist paradigm, a cross-sectional survey was administered to collect data from 538 households in Chitwan and Kavre districts. Samples were chosen through a multi-stage random sampling method. Data analysis was carried out by using logistic regression and descriptive statistics.

The results suggested that technological attributes (i.e., perceived economic and non-economic benefits) and farmers' knowledge base (education) were the main determining factors for technology adoption. While age, formal education, farm size, informal education, economic benefits and non-economic benefits of technology determined the embodied technology adoption; ethnicity, gender, non-formal education, informal education, access to extension services, and non-economic benefits significantly contributed to the disembodied technology adoption. Age negatively influenced technology adoption, whereas women were found to be more receptive to adopting the technologies.

Education had differentiated influence based on the type of agricultural technology. Formal education, which is expected to improve the cognitive and abstract reasoning ability of farmers, was found to be more conducive to the embodied technology adoption. Whereas, non-formal education, which enhances practical skills of farmers through dialectic learning process, was found to be more likely to promote disembodied technology adoption. It was also found that formal education positively contributed in enhancing farmers' human capital and the adoption process of the embodied technology.

The study also revealed that farmers consider both economic and non-economic benefits for maximized utility from new agricultural technologies. This indicates that the utility maximization theory can explain the agriculture technology adoption process better in the Nepali context. Based on these findings, a technology adoption model has been proposed to better explain the agricultural technology adoption process in small farming contexts. The findings of the study contribute to develop policy and program framework in the area of technology adoption. While the study helps to enhance the broader understanding of technology adoption process, it also unfolds some important issues such as the relation of types of education with nature of technologies which demand further research.

Abstract Approved by

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DEDICATION

I would like to sincerely dedicate this thesis to my parents, wife, daughter, family members, farmers, known and unknown teachers, friends and the nature.

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ACRONYMS AND ABBREVIATIONS

ADS	Agriculture Development Strategy
AGDP	Agriculture Gross Domestic Product
APP	Agriculture Perspective Plan
CIMMYT	International Centre for Wheat and Maize
CTEVT	Council for Technical Education and Vocational Training
DADO	District Agriculture Development Office
DoA	Department of Agriculture
DV	Dependent Variable
EoC	Exponential of Coefficient
FAO	Agriculture and Food Organization
FFS	Farmers Field School
GDP	Gross Domestic Product
HCT	Human Capital Theory
ICT	Information and Communication Technology
IDT	Innovation Diffusion Theory
IFPRI	International Food Policy Research Institute
IPM	Integrated Pest Management
IRRI	International Rice Research Institute
IRV	Improved Rice Variety
KR 20	Kuder-Richardson Formula 20
MC	Municipality
MoAD	Ministry of Agricultural Development
MoF	Ministry of Finance
MT	Metric Ton
NARC	Nepal Agricultural Research Council

NAST	Nepal Academy of Science and Technology
NLSS	National Living Standard Survey
NSCL	Nepal Seed Corporation Limited
NSP	National Seed Policy
NTA	National Telecom Authority
OR	Odds ratio
SD	Standard Deviation
SE	Standard Error
SPSS	Statistical Package for the Social Sciences
SRR	Seed Replacement Rate
TEVT	Technical Education and Vocational Training
TPB	Theory of Planned Behavior
TSR	Total Seed Required
TSS	Total Seed Supply
TVDD	Tribhuvan Village Development Department
TYIP	Three Year Interim Plan
UTAUT	Unified Theory of Acceptance and Use of Technology
VDC	Village Development Committee

CHAPTER I

INTRODUCTION TO THE STUDY

There are ongoing debates and discussions globally on agricultural technology adoption to increase productivity and sustainability of the agriculture sector. However, specific measures towards achieving sustainable agricultural productivity are not easily available. While increasing agricultural productivity is critical to meet the increasing demand for food, it is not possible to achieve food security by expanding agricultural land under cultivation (Food and Agriculture Organization [FAO], 2009; Godfrayet al., 2010). So, an innovative approach to enhance agriculture performance has become necessary.

Agriculture is the backbone of Nepal's economic growth and development. It contributes about 33% of the gross domestic product (GDP) and provides employment to two-thirds of the population. Besides contributing to national food security, agriculture is also the main source of household income for 83% of the farming households (Centre Bureau of Statistics [CBS], 2013a). Hence, agriculture is the main basis of livelihood for the majority of people in Nepal.

In spite of its large contribution to people's livelihoods and huge potential for national economic growth, the role of the agriculture sector in these areas has been limited due to various challenges. Some of the major challenges are low crop productivity, high dependence on rain-fed agriculture, lack of agricultural inputs, fragmentation of land, inadequate access to agricultural services, inefficient agriculture systems, unavailability of appropriate technologies, low technology adoption, and climate change (Pyakuryal, Roy & Thapa, 2010; Ministry of Agriculture and Development [MoAD], 2014a). As a result, the performance of this sector has not been satisfactory over the decades. In fact, Nepal's agriculture productivity is the lowest among neighbouring countries. For example, cereal productivity in Bangladesh, China, India, and Pakistan was 3.89, 5.46, 2.47, and 2.82 metric ton/ha respectively, whereas Nepal's cereal yield was 2.37 MT/ha in 2010 (MoAD, 2014a).

These challenges have also been acknowledged in the national agriculture policy frameworks. The Agriculture Development Strategy (ADS) mentions that the agriculture sector is in a low developmental stage (MoAD, 2014a). Similarly, the Economic Survey of Nepal states that the performance of the agriculture sector has continuously been deteriorating from the average annual growth rate of 3.2% in the last decade to just 1.1% in the fiscal year 2012/13 (Ministry of Finance [MoF], 2014).

The consequences of low agriculture growth are potentially devastating on national development. The current agriculture growth rate is far lower than the requirement to meet the national food needs. Thus, food import has increased rapidly over the years. Nepal imported rice equivalent to NRs 4.1 billion in 2009/10 (MoAD, 2010), which increased by five times to NRs 20.9 billion in 2012/13 (MoAD, 2013). This ever increasing food import has negative consequences on national food security, international trade balance and the overall development process of Nepal.

This challenge can, however, be partly managed by introducing new agricultural technologies that can enhance agricultural productivity considerably (Fedar & Zilberman, 1985; Asfaw & Admassie, 2004; Chapagain & Gurung, 2010). Technological change in the form of adoption of improved agricultural production technologies has positive impacts on agricultural productivity and economic growth in the developing world (Nin et al., 2003). So, agricultural technological improvements and their adoption are considered very crucial in increasing productivity, reducing poverty, and ensuring sustainability (Asfaw, 2010; Asfaw, Shiferaw, Simtowe & Haile, 2011; MoAD, 2014a).

Considering the critical role of technology adoption to improve performance of the agriculture sector, it was relevant to undertake an empirical study to understand and explain adoption processes, and to identify major determinants of technology adoption in small rice-farming context in Nepal. This first chapter sets the context of the study, problematizes the topic, identifies the research purpose and hypotheses, and establishes the rationale for the study. In addition, the chapter also lists the limitations as experienced by the study.

Problem Statement

The contribution of the agriculture sector to the national GDP was at 37.4 per cent in FY 2001/02, while it has come down to 33.1 per cent in FY 2013/14 (MoF, 2014). Rice has important share in agriculture GDP but rice productivity growth rate has decreased over the years (MoAD2014a; MoF, 2014). In fact, rice productivity in Nepal was the lowest (2.9 mt/ha) compared to India (3.2 mt/ha), Bangladesh (3.8 mt/ha) and China (6.3 mt/ha) (NARC, 2011). Due to this, the contribution of the agriculture sector to GDP has also been decreasing continuously over the years.

The low rice productivity is due to low utilization of improved technology and continuation of traditional system of production. According to ADS, decreasing rice production results from low adoption of agricultural technology (MoAD, 2014a). The Statistical Yearbook (2012/13) of the MoAD shows that productivity of improved rice variety under irrigated conditions in Terai was 3,802 kg/ha, whereas that of local varieties was only 2,380 kg/ha. This showed about 60% higher productivity in the case of improved rice varieties (MoAD, 2014b). Despite the higher returns, only 15% paddy growers in Nepal have adopted improved verities (CBS, 2011). There could be many challenges to this large technology adoption gap in agriculture. The major challenges include inadequate knowledge on major determining variables for technology adoption and weak understanding how these variables affect on decision making process at small farming context.

Various development programmes and projects such as Promotion of Agriculture Commercialization and Trade (PACT), Hill Research Programme (HRP), Nepal Agriculture Research and Development Fund (NARDF), National Integrated Pest Management (IPM), and High Value Agriculture Programme have been implemented by the government and non-government organizations to improve agriculture productivity through promotion of different types of agricultural technologies in Nepal. But very little has been achieved so far from these programmes in terms of explaining the adoption process and major determining factors in Neapli farming context (Ghimire, Wen-chi, & Shrestha, 2015). In addition, agriculture research and development work in Nepal so far has not properly explored the major determining variables and adoption process according to the types of agricultural technologies considering the smallholding farming contexts. For these reasons, the adoption of new agricultural technologies, for example new seeds, fertilizers, and other management practices, by small-holding farmers have been considerably low (MoAD, 2014a).

This raises some critical research questions: what could be the main reasons for the slow or no adoption of agricultural technologies by farmers? And what are the major variables that influence adoption of new agricultural technologies for smallholding farmers? The central concerns of this research were, therefore, focused to understand what the contributing variables are and how they lead to a higher level of technology adoption to ultimately overcome the major constraints on agricultural technology adoption in Nepal.

Purpose of the Study

The purpose of this survey-based study was to examine the relationship between influencing variables (personal attributes, socio-economic factors, enabling environment, and technological attributes) and technology adoption in small rice-farming systems in the selected research sites.

Research Questions

The following were the research questions of this study:

1. To what extent does education (formal, non-formal, and informal) affect the selected technology adoption?
2. To what extent do socio-economic context, enabling environment and technological characteristics affect technology adoption?
3. To what extent does formal education contribute to human capital development that leads to technology adoption?

Research Hypotheses

The hypotheses for this study were developed after the review of national and international literature related to agricultural technology adoption. A number of research studies have explored the types of explanatory variables in technology adoption (Nelson & Phelps, 1966; Lin, 1991; Dorfman, 1996; Gillespie & Paudel, 2007; Paudel, Gauthier, Westra & Hall, 2008).

Review of literature showed various roles of socio-economic, institutional, and technological factors on agricultural technology adoption (Shakya & Flinn, 1985; Cotlear, 1986; Jones 1989; CIMMYT, 1992; Kaliba, Lin and Milon, 1993; Adesina & Baidu-Forson, 1994; Dorfman, 1996; Ayuk, 1997; Baidu-Forson, 1999; Floyd et al., 1999; Verkuij & Mwangi, 2000;Doss &Morris, 2001; Pattanayak, Mercer, Sills, & Yang, 2003; Joshi & Bauer, 2006; Paudel et al., 2008; Prokopy, Floress, Klotthor-Weinkauf & Baumgart-Getz, 2008). In addition, the seminal works of Schultz (1961) and Nelson and Phelphs (1966) on the role of education on human capital development and role of human capital in economic development were also reviewed. Most of the studies on education, human capital and technology adoption showed positive contribution of formal education to human capital development (Nelson & Phelps, 1966; Huffman, 2000; Aggrey, Eliab & Joseph, 2010).

Hypotheses related to research question 1:

1. H1a: There is an effect of formal education in adopting rice technology at the household level.
2. H1b: There is an effect of non-formal education in adopting rice technology at the household level.
3. H1c: There is an effect of participation of local agriculture groups (informal education) in adopting rice technology at the household level.

Hypotheses related to research question 2:

1. H2a: There is an effect of socio-economic/personal factors (on farm income, farm size, ethnicity, age, gender) in adopting rice technology at the household level.
2. H2b: There is an effect of enabling environment (access to loans, access to markets, and access to extension services) in adopting rice technology at household level.
3. H2c: There is an effect of characteristics of technology (cost of technology, relative benefits – economic and non-economic, ease of use) in adopting rice technology at the household level.

Hypothesis related to research question 3:

1. H3: There is a positive relation between formal education and human capital development that influences agricultural technology adoption.

Rationale and Contribution of the Study

Technology has been vital for both economic growth and social welfare (World Bank, 2008). Much of the economic and social progress in many developed countries in the past few decades has been as a result of technology development and their use. In the case of agriculture, improved agricultural technology is considered instrumental for sustainably increasing food production in developing countries (Lawal & Saka, 2009; Abbullai, 2012) as well as in Nepal (MoAD, 2014b; MoF 2014).

Despite the availability of technologies such as improved rice varieties, which provide high returns, adoption of these technologies has been significantly low in Nepal (MoAD, 2014b). There exists limited knowledge on why adoption is low at small-farming context (Joshi &Bauer, 2006). The literature review revealed that technology adoption is a complex process (Straub, 2009) and this is determined by various factors (and Huffman 2001; Joshi & Bauer, 2006; Deressa et al., 2009). As agriculture is transforming rapidly towards commercialization in Nepal, knowledge is becoming a critical input and the role of education has therefore been instrumental. In this context, it was necessary to identify major determining variables and their level of contribution on agriculture technology adoption in small farming context in Nepal.

The study has generated some findings which are important for development of the agriculture sector and for ensuring national food security. The first outcome of the study has been on building a proper understanding of agricultural technology adoption process in the Nepali context. According to Oster and Thorton (2009), understanding the process of technology adoption in developing countries can help in: (i) predicting adoption patterns; (ii) supporting adopters to sustain the process; and (iii) knowing the most favourable way of marketing new technologies.

The second outcome of the study is identification and quantification of the contributions of the influencing factors in general, and education in particular, that may have differentiated impact according to the type of agricultural technologies. The third outcome is related to the role of formal education in enhancing farmers' human capital.

All these outcomes give a better understanding of the technology adoption process and help to identify the major influencing factors according to the type of technologies (embodied and disembodied). They also enable prediction of the adoption patterns for agricultural technology; and, finally, enhance greater adoption of agricultural technology in small farming context in Nepal.

The study also provides further knowledge of the opportunities of agricultural technology adoption for various stakeholders, including MoAD. The findings also enable in assessing the local farming situations *vis-a-vis* the type of technology adoption to a greater extent so that policy frameworks, mainly agriculture extension strategy, agriculture development strategy, agriculture research - education - extension programmes, can be revised and better implemented. The study will positively contribute to improve agriculture sector productivity, enhance national food security and support the overall national economy.

The study has also generated some new knowledge, especially the differentiated role of education to embodied (material technology) and disembodied agricultural technologies (knowledge based technology). These findings also open new frontiers for further investigations into the agricultural technology adoption process in the Nepali context.

Delimitations

Various types of agricultural technologies for production and post-harvest are available in Nepal, but this study was delimited to improved rice varieties (embodied) and integrated pest management (disembodied) in rice production in Nepal's central region. A set of explanatory variables was chosen from the literature review and some influential variables were identified among the selected variables in small farming context.

Limitations

Although it is likely that embodied and disembodied technologies are correlated, the study did not address the concerns related to the correlation of the technologies. This correlation can be addressed by additional econometric analyses such as using a bivariate seemingly unrelated probit model. Additionally, the study did not check for the endogeneity of the variables included in individual logistic regression models. Endogeneity of variables may make some of the parameters estimate biased/inefficient. Taken together, the findings of this thesis should be taken with caution.

Structure of the Thesis

The thesis is organized into six chapters. Chapter I presents the statement of problem, purpose of research, and research questions and hypotheses. Chapter II provides background information on agriculture, major agriculture technologies in rice cultivation, relevant literature related to adoption theories, and existing strategies and policies in agriculture. The chapter also provides a brief summary of the major influencing factors for the agricultural technology adoption process. Based on the theoretical review and purpose of research, a conceptual framework was developed to guide the research. The third chapter is related to research methodology. It starts with some paradigmatic descriptions and provides a detailed outline of the research methodology. It lays out the research design, sampling design, and data collection methods and describes how data were analysed. It also provides a brief description of the selected statistical tools and methods used for analysis. Results from logistic regression and descriptive statistics of improved rice technologies and the extent of technology adoption in the case of rice are presented in Chapter IV. Based on the findings, a brief discussion focusing on the meaning of the results of the study is presented in Chapter V. Finally, the sixth chapter brings together a summary of findings and theoretical significance of the findings, draws major conclusions, and lays out some implications on policy, practices, and research in order to improve agricultural technology adoption in a smallholding farming context in Nepal.

CHAPTER II

LITERATURE REVIEW

This chapter provides literature review based information on agriculture, agriculture technology adoption process and major determinants of agriculture technology adoption. The first section of this chapter describes the role of the agriculture sector in the national economy and the major agriculture polices and strategies related to agricultural technology adoption and dissemination. The second section provides an overview of the typology of agriculture technologies. The third section provides a brief review of technology adoption theories and the fourth section describes potential determinants of agricultural technology adoption. The final section provides current gaps in research and a conceptual framework for the study.

Role of Agriculture in Nepali Economy

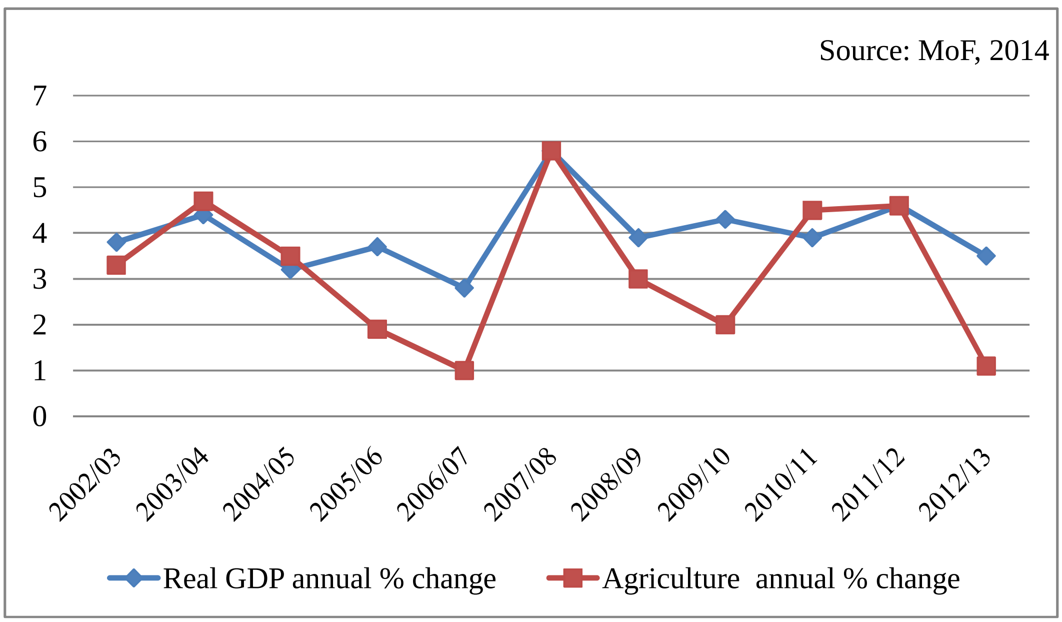
Discussions of agriculture and its political economy are important to understand the context and status of agricultural technology development in Nepal. This section provides a brief analysis of the role of agriculture in the national economy and food security, and reviews dominant agricultural policies in Nepal.

Agriculture and National Economy

Nepal is predominantly an agrarian country. Agriculture is the main contributor to the national economy. Although only 20% (3,091,000 ha out of 147,181 sq. km in 2010) of the total land is under cultivation in Nepal (MoAD, 2010), the agriculture sector provides employment to two-thirds of the country’s population. In addition, people in Nepal are mostly dependent on agriculture for their annual income and maintain their livelihoods.

However, Nepal's agriculture growth rate in the last decade has not been satisfactory. The share of the agriculture sector to the national economy has decreased over the years and the contribution has decreased to one-third of Gross Domestic Product (GDP). Records show that the GDP contribution of the agriculture sector was 33.87 per cent in fiscal year 2012/13 (MoF, 2014). In addition, the Economic Survey carried out by the Ministry of Finance (MoF, 2014) shows that the agriculture sector growth rate (Figure 1) was about 1% in the last decade (2002/03 to 2012/13). This trend shows that the poor and inconsistent performance of the sector compared to other non-agriculture sectors.

Figure 1. Annual Growth Rate of GDP and Agriculture



Despite the decreasing trend of contribution of the agriculture sector in the national economy, the sector still plays an important role in farmers' income and their livelihoods. In this case, the introduction of innovative technologies and their adoption would significantly enhance the performance of the agriculture sector. Hence, there is great need for promotion of agricultural technologies in Nepal.

Dominant Farming Systems

The main farming system is based on integration of crop, livestock and forests; so, it is also known as integrated farming systems. In this type of farming system, households cultivate some land to produce food grains and raise livestock for animal protein (e.g. milk, meat and eggs), draught power and manure. Forests provide fodder, forage and other important goods for feed for livestock, thereby, contributing to cropland soil fertility management (Chapagain & Gurung, 2010; Das & Shivakoti, 2006; and Tiwari, Brook & Sinchlair, 2004).

Another important characteristic of Nepali farming systems is smallholding agriculture. There is no agreed definition of smallholding farming, but the size of land for farming is considered as one the main criteria for defining smallholding farming (Chamberlin, 2007). The existing record of farm size shows that small landholding farming is pre-dominant, with an average farm size of 0.68 ha. According to CBS (2013b), farming households with less than one ha of farm land constitute 67.2 per cent of total farming households (594,081 households). Households with less than 0.5 ha of farm land comprise about 45 per cent of total farming households, holding only about 20 per cent of cultivated land area.

The recent land use trend shows that the per capita agricultural land availability has decreased over the years. In 1961, the per capita agricultural land availability was recorded to be 0.190 ha per person (Shrestha, 1966), which decreased to 0.155 ha per person in 1984 and now is 0.095 ha in 2011 (CBS, 2013a). In 2001/02, the average size of parcels per holding was 0.24 ha, which decreased to 0.21 ha in 2010/11 (CBS, 2013b). The review shows that smallholding farming systems are pre-dominant in Nepal and understanding of the characteristics of small farming systems is important while promoting technology adoption.

Rice Production in Nepal

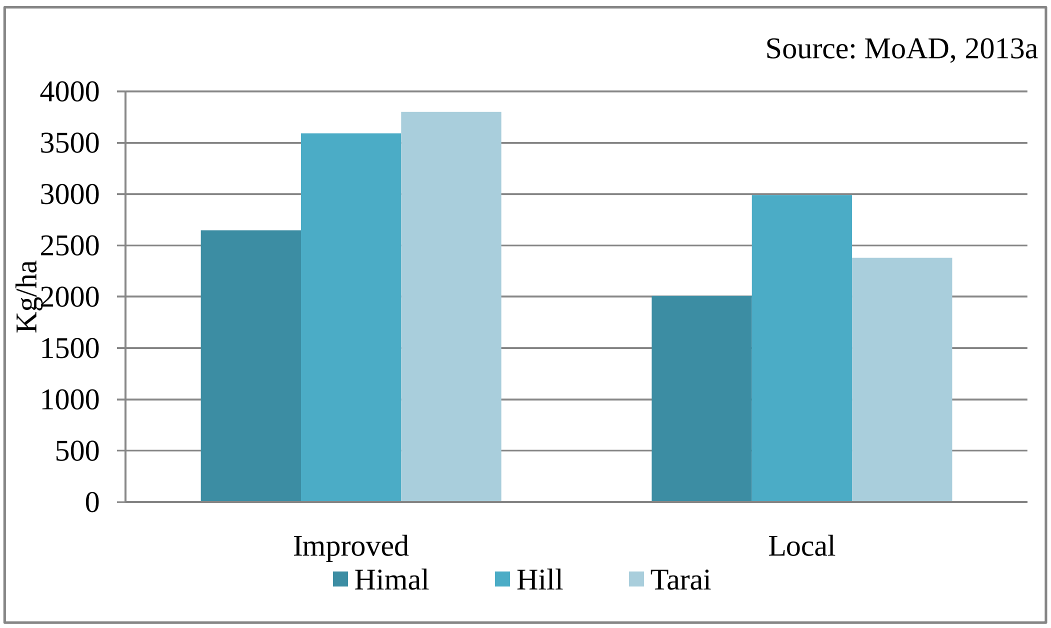
The principal crops of Nepal are cereals, pulses and cash crops. Cereal crops in Nepal are paddy, maize, wheat, millet, barley and buckwheat. The area under cultivation is also dominated by cereal crops, i.e. about 75 per cent of the total cultivated area is occupied by the five main cereals—paddy, maize, wheat, millet, and barley (MoAD, 2010), and among them coverage of rice is the highest. In 2012/13, the total crop cultivation area was 3,339,077 ha, out of which paddy covered about 43 per cent, followed by maize (25%) and wheat (23%) (MoAD, 2014b). The recent statistics of the Ministry of Agriculture (MoAD, 2014b) show that actual crop cultivation area has reduced for rice and maize, whereas the area under wheat has increased. The decreasing rice and maize cultivation area could affect the total national agriculture production. Main reasons attributed to reduction in cultivation area are outmigration of the youth from village and rapid urbanization.

Among cereal crops, rice (*Oryza sativa L.*) is the most important crop in terms of both area and production share. It has major contribution to food security as it forms the major part of the staple food in Nepali diet. Calories from rice form nearly 40 per cent of the total daily per capita calorie supply (Pandey et al., 2010) and more than 24 per cent of the protein supply per capita per day. In addition, rice contributes about 60 per cent of agriculture GDP. Rice is mainly produced in the Terai which shares about 72 per cent of total production in Nepal (MoAC, 2009).

Major technologies or input for increasing agricultural productivity are seeds, fertilizer, irrigation facility and effective pest control mechanisms, improved agronomic practices, among others. The importance of improved seeds in increasing rice productivity is well established. Two important technologies are briefly discussed below.

Improved Rice Variety (IRV). Nepal Agricultural Research Council (NARC) is the main agricultural research agency in the public sector responsible for the supply of breeder and foundation seeds. So far, the national research system has developed about 13 early varieties and 46 main season rice varieties from 1960 to 2013 (NARC, 2014). The first rice variety was *Taichung*, which was released in 1966, followed by *Chainung-242* and *Taichung-176* in 1967. Data also show that *Khumal 11* and *Khumal 8* are the most productive varieties, which give yields of about 10.0 and 9.8 MT/ha respectively.

Figure 2. Productivity of Improved and Local Rice Varieties



The improved seeds have ability to produce more. Figure 2 shows differences in yield between local and improved seeds in different ecological zones in 2012/13 for cereals. For example, the statistical yearbook produced by the MoAD shows that, in the Terai region, improved paddy varieties under irrigation gave a yield of 3,802 kg/ha, whereas local varieties produced only 2,380 kg/ha. Similarly, under non-irrigated conditions, improved varieties yielded 2,191 kg, whereas local varieties yielded 1,520 kg/ha (MoAD, 2014b). This indicates that the improved rice varieties under irrigated and non-irrigated conditions gave 60 per cent and 45 per cent higher yield respectively compared to local varieties.

Although new rice varieties can fetch better returns, the use of improved seeds by the farming households is considerably low and varies by development regions and ecological zones. National Living Standard Survey (NLSS) III shows that the Central Development Region had the highest number of improved seed adopters (23%) and Terai (23.6%) in improved rice adoption among farming households (CBS, 2011) (Table 1).

Table 1

Percentage of Agricultural Households using Improved Rice Seeds

Region	Main Rice
Development regions	
Eastern	4.4
Central	23
Western	22.2
Mid west	12.9
Far west	5.1
Ecological zones	
Mountains	5.3
Hills	6.3
Terai	23.6
Nepal	15.0

Source: CBS, 2011

The smallholding farmers are not generally using improved technologies. Although adequate research information are not available, it is assumed that smallholders generally do not have enough knowledge or input to grow and capital to purchase improved seed; so, use of improved rice seeds by smallholding farmers is low. The agriculture census (2011/12) shows that smallholder farmers are more likely to use traditional rice varieties, whereas farmers with high landholdings are increasingly using improved and hybrid seeds (CBS, 2013b). For example, the agriculture census shows that, in case of small farms with less than one ha, about 70 per cent of farmers used local seeds, whereas big farms (from five to 10 ha) only about 45 per cent of farmers used local seeds.

The literature shows that improved varieties can give higher crop yield compared to traditional varieties, but proper initiatives for enhancing the improved rice seed supply chain, from producing foundation and certified seeds to their distribution so that farmers can easily buy them, are missing. The ongoing programmes during the study period were mainly based on a top-down approach without adequately considering the adoption constraints and behaviour of farmers in small farming context.

Integrated Pest Management (IPM). IPM is an agriculture package of production, which encourages low application of chemical pesticides to reduce human and environmental health hazards. IPM uses biological, cultural and natural pest predators as partial substitutes for synthetic pesticides to manage crop diseases and insects. When chemical pesticides become necessary as a last resort, IPM seeks the most efficient usage possible (Govindasamy, Italia, Thatch & Adelaja, 1998).

The government of Nepal implemented the National Integrated Pest Management Programme (second phase 2008-2013) to ensure food security and environment protection in a sustainable way. The programme helped to enhance the institutional capacities to provide pre- and in-service training in IPM-FFS; and provided support services for farmer groups' resulting in optimized appropriate technologies, more efficient production and better access to markets.

Although IPM programmes are being implemented by the government, there has been no research to identify the major determining factors for IPM adoption at various scales of farm size, group of people, knowledge status and type of education and many more. These programmes are so far primarily focused on reducing the use of pesticide or improving public good, especially improving food safety and environmental conservation.

In summary, rice has played an important role in food security and overall GDP. The government has also invested in research and development of rice-based technologies, but the use of technology has been limited. There are some challenges in terms of easy access to technology and utility of technology to farmers.

Agriculture Policies and Strategies

The national agricultural policy objectives and means are determined by various policy settings (Stoforos, Kavcic, Erjavej, Mergos, 2000). According to Pearson, Gotsch and Bahri (2004), there are mainly three most common objectives of agricultural policies: efficiency (allocation of resources to effect maximal national output), income distribution (allocation of benefits of agricultural production to preferred groups or regions) and food security (the short-run stability of food prices at levels affordable to consumers, reflecting the adequacy of food supplies, and the long-run guarantee of adequate human nutrition).

The government has formulated agricultural policies and strategies to increase productivity, which are important for increasing rural incomes and ensuring equitable distribution. Due to limited availability of highly productive land, it has been envisaged that increasing agricultural production will have to come from intensification of production through adoption of agricultural technology, among others.

After the implementation of the First Five-Year Development Plan in 1956, agriculture was identified as one of the top priority sectors for development. Agriculture has received the highest priority from the Fifth Five-Year Plan (1975-1980) mainly to increase crop productivity and diversify the agricultural base as industrial inputs. The main policy documents in agriculture include the Agriculture Perspective Plan (APP) (1995), National Agriculture Policy (2004), Agriculture Extension Strategy (2007) and the Agriculture Development Strategy (2014) and they are briefly analysed below.

One of the major objectives of the APP (1995) was to transform subsistence agriculture to commercial agriculture through diversification and exploitation of comparative advantages (NPC, 1995). The basic strategy of the APP is technology-driven that emphasizes ensuring adequate supply of some critical inputs such as shallow tube-well irrigation, fertilizer, agricultural roads, improved seeds and research and extension of services.

Similarly, according to the Agriculture Policy (2004), the main objective of agriculture intervention is to ensure food security and poverty alleviation by achieving high and sustainable economic growth through commercial and competitive farming system (MoAC, 2004). The policy aims to enhance agricultural production and productivity; to support commercial and competitive farming system; and to promote environmental conservation and utilize biodiversity resources.

Similarly, the Nepal Agricultural Extension Strategy 2007 focuses primarily on institutional pluralism, privatization and decentralization of extension services (GoN, 2011). But, coordination and linkages among value chain stakeholders are weak from the district to the centre (Thapa, 2010), and the strategy does not focus on the challenges, barriers and opportunities related to the adoption process, role of farmers' education in technology adoption and specific enabling environment needed according to the type of agricultural technology.

Agriculture Development Strategy (2014) is developed to guide and steer the agricultural sector of Nepal over the next twenty years. The ADS considers the level of complexity in the agricultural sector. So, the strategy encompasses the whole value chain process from production to processing sector and trade.

In order to achieve its vision, ADS will accelerate agricultural sector growth through four strategic components of governance, productivity, profitable commercialization and competitiveness while promoting inclusiveness (both social and geographic), sustainability (both natural resources and economic), development of the private sector and the cooperative sector, and connectivity to market infrastructure (e.g. agricultural roads, collection centres, packing houses, market centres), information infrastructure, Information Communication Technology (ICT) and power infrastructure (e.g. rural electrification, renewable and alternative energy sources).

Using the framework proposed by Pearson et al. (2004) as discussed above, the agriculture policy frameworks in Nepal are found to be weak in terms of maintaining efficiency, promoting equity among stakeholders and promoting technology adoption.

In the efficiency domain, the allocation of public resources through the MoAD and from other non-governmental sectors is not found contributing to sustainable agriculture in general and promotion of improved technology in specific. This can be exemplified through the existing performance of the agriculture sector. As discussed earlier, the performance of agriculture, which remains the backbone of the economy, shrunk continuously over the past two decades. The role of private sector in promoting technology is still in a rudimentary stage. Despite huge investments in irrigation, only about 25 per cent of arable land has access to irrigation facilities and the remaining agricultural land is still rain-fed. As mentioned in the policy document, agricultural diversification to reduce risk and ensure sustainability has also not been achieved.

The income distribution or equity among the groups that are targeted by policies is not found equitable. Although the policy emphasizes subsistence farming in rural areas, the delivery systems, especially extension systems, are not appropriately designed to meet the needs of small farming in getting appropriate support from the government. In terms of technology adoption, there is a dearth of information such as why and how smallholding farmers adopt technology. One of the reasons for failure of technology adoption is lack of appropriate technologies that are suited to smallholding farmers. In addition, poor farmers in rural areas have been experiencing poor and inadequate agriculture infrastructure such as roads and cold storage facility that also limit the ability of farmers to adopt technology (MoAD, 2014a).

Another important objective of the agriculture policy framework is to ensure food security. This objective has also not been achieved in Nepal. As discussed above, food import has significantly increased over the years. Nepal imported rice equivalent to NRs 4.1 billion (MoAD, 2010) in 2009/10, which increased by five times to NRs 20.9 billion in 2012/13 (MoAD, 2013).

In addition, the policy and strategies, including those in technology adoption, are being prepared mostly following a top-down approach and externally driven concepts rather than originating from local constraints and needs. The implementation of these policies has been a great challenge as they do not necessarily address the constraints faced by the farmers. The agriculture policy frameworks emphasize technology adoption, but they seriously lack proper understanding of the socio-economic context of farmers and the ability of farmers to use and relevancy of technology to smallholding farmers. Additionally, the technology adoption processes were also weak in terms of developing appropriate mechanisms for implementation, assessing resource needs and learning to improve approaches, among others.

Technology and Typology of Agricultural Technologies

This section reviews literature related to agricultural technology and technology adoption and theories related to technology adoption and their possible use in agricultural technology adoption. Based on literature some determinants of technology adoption by smallholding farmers are discussed.

Technology

The word technology comes from the Greek word *technologia*, which is derived from *techne*, meaning 'craft', and 'logia', meaning 'the study of'. In its modern usage, technology refers to the practical application of knowledge in a particular area. Various authors define the term "technology" in different ways. Rogers (1995) uses the words 'technology' and 'innovation' synonymously and defines technology as the design for instrumental actions that reduce the uncertainty in the cause-effect relationship involved in achieving a desired outcome. Enos and Park (1988) define technology as "the general knowledge or information that permits some tasks to be accomplished, some service rendered, or some products manufactured".

Typology of Agricultural Technology

Sunding and Zilberman (2001) provide a set of classification for agricultural technologies. They include embodiment of innovation in capital goods and products; types of impact of innovation (increasing yield, decreasing cost, improving product quality, and protecting health/environment); and form of innovation, (mechanical innovations, biological innovations, chemical innovations, agronomic innovations, bio-technological innovations, and informational innovations). Based on the nature of this study and to maintain simplicity, the embodiness of innovation is considered for this study.

According to Sunding and Zilberman (2001), innovations can be divided between those that are embodied in capital goods or products and those that are not embodied in any physical item. Example for this can be new seeds, agriculture machines, pesticides and chemical fertilizers, whereas a new process of soil and water management to improve irrigation performance, and integrated pest management are considered a disembodied innovation. Many disembodied innovations are practical knowledge that can be shared by many users. There is not much investment in research and development (R&D) activities, leading to disembodied innovations because of the difficulty in capturing the benefits of these innovations.

Swanson (1997) and Swanson and Samy (2002) also classify agricultural technologies based on embodiness and classified as ‘material technology’ and ‘knowledge-based technology’. According to them, material technology is a type of technology where knowledge is embodied into a technological product such as tools, equipment, agrochemicals, improved plant varieties or hybrids, improved breeds of animals and vaccines. They also mentioned that, for transfer and adoption of material technology to farmers generally involves the production, distribution, and sale of specific products such as seeds, implements, agrochemicals, and other production inputs. Therefore, the transfer process for material technology is generally simpler and carried out mostly by private groups (also called as private or proprietary goods). Hence, usually, the private sector is best suited to produce and distribute material technology. The ‘knowledge-based technology’ (disembodied) is a set of knowledge with specific technical knowledge and management skills which have strong elements of ‘public goods’. These are generally disseminated through public extension systems. This is, however, a fussy or floating distinction of these groups as some conceptual overlaps exist.

Based on the classification and description of the technologies as mentioned above, the two technologies, i.e. improved rice varieties (IRV) and integrated pest management (IPM), can be considered as embodied and disembodied technologies respectively. The study has used this classification and type of technology for further analysis of the determining factors for technology adoption.

Adoption Theories

Adoption is acceptance and use of new agricultural technologies by the farmers. Adoption is, however, a dynamic process that is determined by various factors such as farmers’ perception of the benefits of technology, efforts made by the extension services to disseminate these technologies to farmers, risks involved, costs involved, profitability and complexity, i.e. the likelihood that the farmers will be able to apply it correctly. Straub (2009) mentioned that ‘there is no one model for understanding the processes in which an individual engages before adopting a new innovation. Whereas the results of adoption theory are measured in terms of behavioral change, the predictors of that behavioral change can be understood through contextual, cognitive, and affective factors. Existing theories deal independently with these factors but no one theory accounts for all three. Various adoption theories are available in the literature and some of the relevant theories are briefly discussed below.

Utility Maximization Theory

There are two general types of theories that help to explain technology adoption decision processes of farm households in developing economies. They are profit maximization and utility maximization. The proponents of the profit maximization theory believe that adoption of agricultural technologies by farmers is an essential pre-requisite for economic prosperity (Nkonya, Schroeder &Norman, 1997). Profit maximization theory views farmers, as profit maximizers, in a perfectly competitive market. So, the theory assumes that farmers, despite being poor, allocate their resources efficiently (Schultz, 1964, Thapa, 2008). Some studies have, however, questioned the allocative efficiency of smallholding farmers (Bliss & Stern, 1982).

As an alternative to the profit maximization theory, economists have proposed the Expected Utility Theory or Utility Maximization Theory. The theory is interested in people's preferences or values and assumptions about a person's preferences (Fishburn, 1969). The theory holds the belief that when individuals purchase goods or a services, they strive to obtain the most amount of value possible, while at the same time spending the least amount of money possible. The expected utility theory, therefore, states that a farmer compares the innovation with the traditional technology and adopts it if the expected utility from adopting exceeds the expected utility of the traditional technology (Batz, Peters, & Janssen, 1999). The theory has been used in appropriate agricultural technology adoption process (Ogada, Mwabu, & Muchai, 2014; Borges, Foletto & Xavier, 2015).

According to Moschini and Hennessy (2001), agriculture production systems have a lot of uncertainties and risk. They include production uncertainties (the amount and quality of output that will result from a given bundle of inputs are typically not known with certainty); price uncertainties (the market price for the output is typically not known at the time these decisions have to be made); technological uncertainties (randomness of new knowledge development-affects production technologies in all sectors); and policy uncertainties (policies have impacts taxes, interest rates, exchange rates, regulation, provision of public goods, and so on). Hence, they argued that the expected utility model provides the most common approach to characterizing rational decisions under risk and uncertainty in agriculture sector.

In developing countries, markets are imperfect (type of market structure showing some but not all features of competitive markets) and institutions are not mature; hence, farmers have to face a lot of stochastic production risks. In this context, smallholding farmers are viewed primarily as exploring for maximizing the utility from new technologies by adjusting various factors instead of depending only on one factor such as economic profit. In fact, farmers make a lot of trade-offs between economic profits with other equally important non-economic benefits. Thus, they cannot be typical profit maximizers in financial terms.

Technology adoption is a complex process. Straub (2009) mentions that the technology adoption process is a complex, inherently social and developmental process; whereas Venkatash, Morris, Davis and Davis (2003) mentions that the adoption process follows the psycho-social thought process. This reinforces the argument that farmers may prefer multiple benefits in economic, social, personal, and environmental aspects. Hence, the concept of utility maximization theory has gain additional attention.

The theory posits that the decision to ‘adopt’ or ‘not adopt’ is based on whether the new technology will bring more utility to farm households than the technology being used (Caviglia-Harris, 2003). As rational consumers of agricultural technologies, farmers are expected to choose technologies that give them maximum utility - economic and non-economic benefits. So, it is argued that adoption decision is a behavioural response arising from a set of alternatives and constraints, which is dependent on the level of knowledge that the decision maker has.

According to Venkatesh et al. (2003), many competing theory-based approaches have been used to make enquiries into the adoption behaviour, i.e. to know what determines an individual’s acceptance of or behaviour towards new technology. For example, the Theory of Planned Behaviour (TPB) (Ajzen, 1991) helps to understand and explain the causal factors of adoption which are expected to be dependent on beliefs, attitudes, subjective norm, and perceptions of behavioural control (Hernandez & Mazzon, 2006).

There is a general agreement that these theories are useful for understanding farmers’ behaviour while identifying the major influencing factors. There are also some limitations on these theories. These behavioural theories are based on the assumption that prospective technology adopters use rational behaviour while selecting technology. Rational behaviour is mainly determined by the level of knowledge, i.e. education, but this has not been adequately considered by the behavioural theories. So, unless knowledge or education is considered in these theoretical analyses, the technology adoption decision-making process may not be fully understood and explained. Nelson and Phelps (1966) suggest the role of human capital or education in development and that education may contribute beyond its role as a mere factor of production. The potential role of human capital theory is briefly explained below.

Human Capital Theory

The concept of human capital refers to the knowledge, abilities and skills of the individuals that can be used in the activities that stimulate the innovation process (Schuller, 2001). Idea of human capital basically originated from Marshal's idea (during the 1930s) that 'the most valuable of all capital is that invested in human beings' (in Principles of Economics). According to the human capital theory, human capital contributes to output just like other factors of production. Huffman (2000), therefore, argues that human capital is one of important factors for technology adoption and improving agricultural productivity.

The concept of human capital can be categorized in various ways from each perspective of academic fields. The first viewpoint is based on the individual aspect. Schultz (1961) recognizes human capital as 'something akin to property' against the concept of labour force from the classical perspective. There is the second viewpoint on human capital itself and the accumulation process of it. This perspective emphasizes knowledge and skills obtained throughout educational activities such as compulsory education and vocational education. The third aspect is closely linked to the production-oriented perspective of human capital.

So, human capital is a composite form of resources that impact improving agricultural productivity and the allocative ability of farmers to deal with disequilibria and unexpected change process. Frank and Bemanke (2007), therefore, defines that human capital is 'an amalgam of factors such as education, experience, training, intelligence, energy, work habits, trustworthiness, and initiative that affect the value of a worker's marginal product'. Among them, education is widely recognized as the most important form of human capital (Hufffman, 2000) that enhances the marginal physical products of workers (Aggrey, et al., 2010).

Welch (1970) condenses two effects of human capital on labour productivity, i.e. 'work effect' and 'allocative effect'. He argues that these effects are facilitated by education. For work effect, he assumes that firms produce only one good with the production factor education and that other resources are given. The worker effect refers to the positive marginal productivity of education with respect to that particular good. Workers with a higher level of education are assumed to be more efficient in working with the resources at hand, i.e. these workers produce more physical output. According to Welch (1970) the worker effect is presumably "related to the complexity of the physical production process"(p. 43).

Second, the allocative effect points to the greater (allocative) efficiency of better educated workers in allocating all input factors to the production process between the alternative uses. According to Welch (1970), allocative effect is present if, in addition to education as an input factor, two (or more) other inputs are included in the production function. If just one good is produced with two inputs, education may also help to select the efficient quantities of inputs. In equilibrium the marginal value product of the inputs should equal the price of the inputs. In fact, education seems to provide the skills to make better decisions based upon the available information.

Pudasaini (1983) in Bara and Gorkha districts and Dhakal, Grabowski and Belbase (1987) in Nuwakot district carried out some studies in Nepal in 1980s and assessed the role of education by using the concept of Welch (1970). Both studies found that education has played important role in enhancing work and allocative effects of farmers. But, Nepal has witnessed a lot of changes in education, political and socio-economic fronts and these changes are assumed to have affected in education and agriculture relations by now.

Contribution of education in human capital formation. Role of education in human capital formation has been theorized by many researchers, but there is still inadequate empirical research on this issue. Gallacher (1999) explores the nexus between human capital, education and technology adoption in Brazilian agriculture. He considers the ‘work effect’ relates to education as an input that allows more output to be produced from a given input vector and ‘allocative ability’ allows adaptation of the input - (and, in multi-output firms) output vector to changes in price signals and other situations.

Based on this research, the study used agricultural productivity increment per hectare achieved by farmers who adopt the technology (improved rice varieties) against non-adopters as ‘work effect’ and the adoption of agricultural technologies as ‘allocative effect’.

Technology Adoption

According to Rogers, ‘adoption is a decision to make full use of an innovation as the best course of action available’ (Rogers, 1995, p. 171). In adoption literature, there are two fundamental concepts that need to be understood. The first one is type of adoption and the second one is nature of adoption. Feder et al. (1985) categorizes three distinctions in types of adoption: i) individual vs. aggregate adoption; ii) singular vs. package of technologies available for adoption; and iii) divisible vs. non-divisible technologies. This study is more related to the first type of technology adoption. The individual level adoption generally involves an internal deliberative process and is manifested as a dichotomous decision, whereas the aggregate adoption behaviour observed as the diffusion of technology which can be measured at aggregate level of use of a particular technology among one specific group of farmers or within one particular area.

In the case of nature of adoption, there are two variants. The first one is 'degree of use' which is considered as a quantitative measure of the extent of adoption. The second is about 'intensity of adoption', which can be measured at the individual farm level in a given time period by the amount or share of farm area utilizing the technology. Due to the nature of the study, the 'degree of use' of agricultural technology by the farmers has been considered in this study.

Major Determinants of Technology Adoption in Agriculture

The study of technology adoption in agricultural settings dates to the seminal work by Griliches (1957). Griliches studied factors responsible for the wide cross sectional differences in the past and current (at that time) rates of use of hybrid corn seeds in the United States (Griliches, 1957). Later, Feder et al. (1985) worked extensively on agriculture adopting relating to developing countries. Since then the amount of literature on this subject has expanded tremendously.

A large body of literature exist that attempts to explain the socioeconomic characteristics of decision-makers that tend to speed adoption. Although there are varieties of literature available but a seminal work by Prokopy et al. (2008) is considered as very elaborative and extensive in the field of agricultural technology adoption. This paper reviewed fifty-five papers published in academic journals focusing on adoption of agricultural best practices in the USA. The paper has reviewed different factors and determinants and categorized in four characteristics, i.e. capacity, attitudes, environmental awareness and farm characteristics. The study found that education level, capital, income, farm size, access to information, positive environmental attitudes, environmental awareness, and utilization of social networks that are more often positively, rather than negatively, were all associated with adoption rates.

Based on the review of wide range of literature from published studies in Nepal and outside, the following adoption variables were found. They include education (formal, non-formal and informal), personal characteristics (age, gender, ethnicity), socio-economic status (land size, annual income), enabling factors (agriculture loan, market distance, agriculture extension services) and technological attributes (ease of use and benefits).

Education

The knowledge-based economy, new technologies, the growing speed of technological changes and globalisation all influence the needs to improve the population's skills and competences (Colardyn & Bjornavold, 2004). Hence, the acquisition and use of knowledge is also a prime factor for agriculture technology adoption and overall agricultural development in the changing context in Nepal. Berliner (1986) suggested that three important types of knowledge which can also be applicable to agriculture technology adoption process. They are content knowledge (knowledge or skill to be learned by the student), pedagogical knowledge (educational theory of factors that affect learning), and pedagogical content knowledge (unique ways in which content knowledge is conveyed to learners in specific settings).

Education is the major source of knowledge acquisition and skill development. Cotlear (1989) categorises different types of education: formal, non-formal and informal. All three types of education are important in the adoption of technologies. They are briefly described below.

Formal education. According to Coombs and Ahmed (1974), formal learning is defined as something that takes place in an "institutionalized, chronologically graded and hierarchically structured educational system" (p. 8). So, formal education entails learning that occurs within an organised and structured context and designed for intentional learning with a formal recognition.

Literature showed various positive impacts of formal education. Higher education is associated with longer life expectancy, improved health, reduced participation in crime, and greater civic participation. These correlations have been known for a long time (Green, 2009). The role of formal education on developing human capital is also well recognized. Formal education is widely considered to be the most important form of human capital (Becker, 1994) in a dynamic political and economic environment where new technology and information are regularly developed (Gardner and Rausser, 2001). Formal education through schooling can provide an externality benefits by increasing farm production and better allocation of resources.

Although these impacts of additional schooling are increasingly becoming understood, much less is known how does schooling enhance individuals' cognitive skills and non-cognitive effects thus enabling them to perform more complex tasks in agriculture? This has been one of the important questions in this study.

According to Weir (1999) formal Education may have both cognitive and non-cognitive effects upon labour productivity. She argues that cognitive outputs of schooling include the transmission of specific information as well as the formation of general skills and proficiencies. These transmissions of information through increasing literacy and numeracy may help farmers to acquire and understand information and to calculate appropriate input quantities in a modernizing or rapidly changing environment. She also argues that education also produces non-cognitive changes in attitudes, beliefs and habits. These are also useful to increase ability to moderate risk, optimize opportunities and adopt new technologies. Hence, formal education may directly influence agricultural productivity via one or more of the routes described above.

Evidence of production externalities was presented in Weir and Knight (2000), who analysed the internal and external benefits of schooling in rural Ethiopia using both average and stochastic frontier production functions. They showed that education externalities in production may be primarily mediated through the role of education in shifting the production frontier outwards (e.g., through the adoption of agricultural technologies).

Non formal education. It is increasingly recognized that school alone cannot provide quality basic education for ‘all’. Millions of young people do not have opportunity to attend formal education due to the multiple and often inter-connected challenges they face such as poverty, school distance, gender bias, disability and social discrimination. So, those who do not have formal education, diverse forms of provision through different learning pathways are required. Non-formal education is one such pathway.

Non-formal learning can be conceptualized as “any organized, systematic, educational activity carried on outside the framework of the formal system to provide select types of learning to particular subgroups in the population” (Coombs & Ahmed, 1974, p. 8). Examples of non- formal learning include training, conferences, seminars and workshops. Non-formal education is generally targeted to a particular subgroup of a population (e.g., progressive farmers). It is generally found in the realms of non-academic associations; it is flexible, learner centred and motivated, and is highly adaptable.

Non-formal education has various merits. According to Yasunaga (2014), multiple types of non-formal education focus on adaptive learning; it constitutes an integral part of lifelong learning; and it has positive impact on economic productivity.

Another important feature of non-formal education is about pedagogical approach it uses during information and skills transfer. According to Delors (1996) non- formal education has proven to be effective for critical pedagogy and innovative approaches and it goes beyond the two pillars of learning, ‘learning to know’ and ‘learning to do,’ that used to be the main focus of formal education in the past, to also include the other two pillars - ‘learning to be’ and ‘learning to live together’.

According to Odeyemi (2003), non-formal education can contribute to three domains of learning that can help in technology adoption process. They are cognitive domain, psycomotive domain and affective domain. In the cognitive domain, how the farmers can gain knowledge is addressed. There is a useful information (related to technology adoption) to disseminate which farmer must know and understand. For example, it is important for farmers to know the process of using biological pesticide for controlling insects in rice. In the psychomotive domain, emphasis is given on skill. Once farmers know the process of the using the biological pesticides, they need to get practical skill on how to use them such as preparing pheromone traps. Lastly, the affective domain focuses on attitudinal change. Farmers have their age-long beliefs and thing they cherish. They have acquired these beliefs through the process of acculturation or informal education. The non-formal education helps to change these status-quos through adopting a strategy of subtleness, perseverance and persuasiveness.

Non formal education can be of different types. According to Yasunaga (2014) they can be categorized as: i) remedial and supplemental non-formal education to satisfy unfulfilled provision by formal education, targeting school dropouts, out-of-school children and young people and adults who have missed schooling; ii) non-formal education which includes vocational training and a skills development component; iii) experimental and innovative non-formal education, some of which involves greater independence from governments, to respond to emerging learning needs as societies evolve. This study has used training/ skill development and experimental / innovative type of non-formal education.

In Nepal, the Department of Agriculture (DoA) is the main agency to provide agricultural training in various aspects such as cereal crops, vegetables, livestock and fruits. District Development Agriculture offices in each district have their regular annual programme and they run these training, organize workshops and other specific events to provide specific knowledge and skills to farmers.

Informal education. Informal learning is identified as "the lifelong process by which every person acquires and accumulates knowledge, skills, attitudes and insights from daily experiences and exposure to the environment" (Coombs & Ahmed, 1974, p. 8). Learning occurs in a wide variety of contexts (Brookfield, 1986), the majority of which occur in an informal setting beyond dedicated formal learning institutions (Smith, 1999).

From a constructivist viewpoint, learning is defined as the meaning individuals construct from their experiences (Guba & Lincoln, 1994). It recognizes the relationship between past and current experiences, and this is the context where learning takes place. By examining the lives of farmers from this perspective, there can be a deeper understanding regarding the meaning that farmers assign to continue knowledge acquisition throughout their careers. The learning of a farmer is a continuing, developmental process rather than a one-time event.

This study viewed farmers' knowledge acquisition is also a social construction stemming from the belief that knowledge is constructed from the world in which they live. The study also aimed to consider many contextual variables which comprise the complex reality in which farmer work that helps to get a holistic understanding of farms and farming context.

The applied literature on the effect of education on innovation in developing countries is limited (Weir & Knight, 2000). However, Jamison and Moock (1984) test the effect of schooling and extension contacts on the adoption and diffusion of agricultural innovations in Nepal. They find that schooling does influence adoptive behaviour but that household income mediates the adoption decision. Individual extension contacts are less important than extension activities in the site in influencing the adoption and spread of innovations, providing evidence of an externality effect of innovation.

Education and agriculture technology adoption. Education enhances one's ability to receive, decode and understand information (Nelson & Phelps, 1966) and it is hypothesized that education may also facilitate adoption of new technology. Lin (1991) shows that, although new technology brings some risks mainly due to imperfect information, education would still be an important factor for new technology adoption in agriculture. Hence, farmers with relatively high level of education may have a higher probability of adopting new technologies than those with relatively little education (Lin, 1991).

Several studies were carried out to assess the role of education on technology adoption in developed countries (see Lin 1991; Dorfman, 1996; Gillespie & Paudel, 2007;Paudel et al., 2008) and these studies show the fact that education plays a positive and significant role in household's probability of adopting new agricultural technology.

Deressa, Hassan, Ringler, Alemu and Yesuf (2009) observe education significantly increases soil conservation and changing planting dates as an adaptation method. They reveal that a unit increase in number of years of schooling would result in a 1% increase in the probability of soil conservation and a 0.6% increase in change in planting dates to adapt to climate change.

Gillespie and Paudel (2007) mention some conditions are required to meet for adoption of technologies. Those conditions include: availability of sufficient information; existence of a favourable attitude towards technology; possession of economic means to acquire technology; physical availability of technology; a positive impact of the technology on the producer's net return; the willingness of the producer to alter management practices to adopt the technology; and the applicability of the technology to the producer's operation. Out of all these conditions, three are related to knowledge management. Hence, knowledge which can be generated through different forms of education is vital for technology adoption.

Group membership has positive correlation with technology adoption. Producers with membership in organizations or group would be likely to acquire more information on new products training and seminars and through informal exchange of information and ideas. Nzomoi, Byaruhanga, Maritim and Omboto (2007) show a positive relation of group membership with the adoption of technologies related horticultural export produces in Kenya.

Joshi and Bauer (2006) show that the key and significant variables affecting demand for rice variety are dependent on farm and farmer characteristics, i.e.

education level, experience of the farmers, and source of seeds and characteristics of technology (such as easy threshability, early maturity, and less irrigation requirement). According to them, farmers who are educated give preference to early mature variety and easy threshability. This is one reason why *Radha 4*was preferred over *Janaki (*late maturing and hard to thrash*)*. This is because *Janaki* is a variety with longer maturity duration and difficult to thresh manually.

From these findings, it is clear that education can significantly contribute to adoption of new technologies in Nepali rice farming as well. Some studies have been carried out in Nepal related to technology adoption and their determining factors (see Pudasaini, 1983; Shakya & Flinn, 1985; Ani, Ogunnika & Ifah, 2004; Joshi and Bauer, 2006; Deressa et al., 2009) which show some linkages of education with technology adoption but no substantive evidence are drawn so far.

Socio-economic, Technological, Enabling and Personal Factors

A rich body of literature is available related to socio-economic factors that determine technology adoption in both developed and developing countries. The studies, however, identify various kinds of determinants based on types of farmers, accessibility and socio-economic development. They include farm size, family labour, farm and non-farm income, capital, access to information, extension services available, farmers perceptions (profit, tolerance, quality, adaptability), family wealth, livestock ownership, access to credit, debt to asset ratio, productivity potential of technology, land ownership, soil quality, perceived risk (Adesina & Baidu-Forson, 1995; Dorfman 1996; Kaliba, et al., 2000; Joshi & Bauer, 2006; Paudel et al., 2008; Prokosy et al., 2008).

Some studies carried out on technology adoption in rice in the Terai show various factors responsible for technology adoption. Shakya and Flinn (1985) show that availability of irrigation facility, tenure status and access to credit were important, whereas Joshi and Bauer (2006) show that the production and consumption attributes were responsible for adoption of rice technology.

Farm size is frequently analysed in many adoption studies (for example, Shakya & Flinn, 1985; Doss & Morris, 2001). This is perhaps because farm size can affect and in turn be affected by the other factors influencing adoption. Firm size has been a factor associated with early adoption in many studies. In economics literature, perhaps the most consistent factor associated with early adoption is firm size. It has been suggested that larger firms can take advantage of returns to scale or larger gross earnings. Larger firms are also less likely to face credit constraints because they have more collateral. They can also bear risk (Prokopy et al., 2008).

Non-farm income from non-agricultural employment proved quite important in fostering adoption of technology practices. Cash is essential in the buying technology, hiring of labour and management technology. At existing productivity level and production scale, it might be difficult for small farming systems in Nepal to invest in technology.

Floyd et al. (1999) finds that the level and distribution of adoption of selected crops were significantly influenced by extension input and by ethnicity. The study also shows that greater extension input increased awareness of technology and also increased the rate of trying and thus adoption rates. The study revealed the adoption rates were significantly lower amongst some ethnic groups, and the influence of agro-ecological zone, access to adoption and gender were much smaller in technology adoption.

Age is typically measured as the average age level of the entire household or just the household head. There is often inconsistency of evidence about the effect of age on innovativeness. In Cotlear (1986), age is shown to have a negative influence on adoption of biological and chemical inputs, seemingly because older farmers are more conservative while carrying out a study on farmers' education and farm efficiency in Peru. However, Strauss et al. (1991), in a study of role of education and extension in adoption of technology in Brazil, has found that age has no effect on adoption.

Gender usually measures the proportion of men and women in the household and captures different adoption rates of technology by men and women. For most of the technologies, generally head of the households are likely to adopt new technologies. This variable also reflects the resource capacity of the household (Pattanayak et al., 2003). The variation in adoption is considered due to the unequal access to men and women to productive resources. Evidence suggests that female-headed households are less likely to adopt technologies than male-headed households (CIMMYT, 1992; Doss & Morris 2001).

The role of the media such as radio, television and newspaper would be generally important to convey message to farmers even in remote areas. For example, television can provide quick and easily understandable information even to illiterate farmers in remote areas. For example, Khanal (2013) has found that radio had a positive contribution to agricultural technology adoption. In addition, Abbas, Sheikh, Muhammad and Ashfaq (2003) also found that electronic media has a central role in facilitating the exposure of farmers to the latest information. Nwankwo and Orji (2013), however, shows that messages shared through media are not easy to understand; so it does not have a positive impact on the agricultural technology adoption process.

Distance to market is important to access appropriate information in time. A review of adoption in agriculture carried out by Pattanayak et al. (2003) showed that 26% of the adoption studies used this variable to assess its influence on technology adoption. The variable was mostly significant with the expected negative correlation; as distance increased, adoption decreased.

A lot of literature shows the role of technological attributes in agricultural technology adoption. Roger (1995) argues that technological attributes such as relative benefits, cost, complexity, and compatibility are important factors in technology adoption.

It is believed that technology adoption is dependent on the perceived relative benefits and cost of technology. The benefits of adoption can include reduced costs or better production from new technology or having other non-economic benefits. The relative benefits can be measured through subjective estimates of yield or indirect effects attributed to current levels of related activities such as farm income. The statistical significance varies, with 58% of the studies showing a positive correlation with benefits (Pattanayak et al., 2003).

In a study on the adoption of live hedges, the profitability of the technology has a significant and positive relationship with adoption (Ayuk 1997). In this study, by-products (fodder, fuel wood, fruits, etc.) and garden products leading to cash income are a primary incentive to adoption. A study carried out by Baidu-Forson (1994) shows that the potential for short-term profits is positively correlated with the adoption of land-enhancing technologies in Niger. Similarly, Franzel's (1999) study on the adoption of improved tree fallows in Africa concludes that adoption increases if high-value by-products can be produced.

Economists have accumulated evidence from consumer demand research. The research showed that consumer demand for products is significantly affected by perceptions of the product (Jones 1989; Lin & Milon, 1993; Adesina & Baidu-Forson, 1995). In a study carried out by Adesina and Zinnah (1993) on the adoption of different rice varieties in Sierra Leone showed that farmer's perceptions were significant in explaining adoption process. The empirical model generated by this study included variables measuring perceptions of taste, yield, ease of cooking, and ease of threshing the harvested rice.

Another study carried out by Adesina and Baidu-Forson (1995) assessed the effects of farmer perceptions on the adoption of improved sorghum varieties in Burkina Faso and improved rice varieties in Guinea were shown. The study elicited that farmers' perceptions of technology characteristics significantly affect their adoption decisions. The study provided a strong case for adoption studies to expand the range of variables used away from the broad socio-economic, demographic and institutional factors to include farmers' subjective perceptions of the characteristics of new agricultural technologies.

Based on the literature review, the study selected some important variables and these variables were associated with the selected theories i.e. utility maximization theory, the theory of planned behavior and human capital theory. Utility maximization theory is mainly based on the belief that the farmers preferred to maximize the utility from new technology compared to traditional one in the uncertain conditions (production, price, technology and policy uncertainties) and these are the important features in agriculture sector in Nepal. The utility maximization can be achieved by enhancing benefits from technologies. In this case, economic benefits, non-economic benefits (availability of rice straw and perceived impact on human health), cost of technologies and ease of technologies can contribute in influencing on overall utility maximization process.

Similarly, the theory of planned behavior has three constructs (attitude, subjective norms and perceived control behavior) that help to understand the technology adoption processes. The personal attributes (gender, age, education and ethnicity), socio-economic factors (on farm income, farm size), enabling environment (role of media, access to market/ distance, knowledge and agricultural loan) and technological factors (economic and non-economic benefits) influence farmers to change their perception or attitude on new technologies; informal education and non-formal education influence on subjective norms whereas ease of use of technologies affect on perceived control behavior. Similarly, education (formal, non-formal and informal) can influence human capital formation as highlighted by Huffman (2001).

Summary of Literature Review

The literature review showed that the performance of agriculture sector is poor. The sectoral productivity has not improved as per investment; food security is an important challenge; food import has increased and the role of agriculture in the national economy is decreasing. Among many other challenges, low adoption of new technologies among farmers is widespread.

The agriculture policy analysis showed poor performance in improving the sector. The assessment of delivery of the objective of policies by using efficiency, equity and food security framework (Pearson et al., 2004) shows many barriers and challenges. The efficiency in terms of improving sectoral productivity, generating adaptive technologies, involvement of private sector, developing adequate infrastructure and diversifying agriculture have not been successful. Similarly, for equity, despite the policy being said to be supportive of smallholding, adequate support for research and development of smallholding-sensitive technologies is yet to be developed and transferred. The last one is about food security. The status of food security has been seriously challenged due to low productivity of cereal crops and other agricultural products and food import has been increasing over the years.

Theoretical literature of technology adoption indicates that the adoption of new technology can be analysed from a sociological or economic viewpoint. Economists view that profit maximization is the main factor that drives early adoption. Economist also believe adoption of agricultural technology by farmers is an essential pre-requisite for economic prosperity (Nkonya et al., 1997) when they are given full market opportunities.

But, this approach is criticized by various other groups such as sociologists and behavioural economists. They argue that farmers are located in a larger dominant economic and political system that could affect their production behaviour and they are fundamentally characterized by partial engagement in market, which are often imperfect or incomplete (Ellis, 1992). In addition, at the household level, there is always the existence of trade-offs between profit maximization and other household goals as they have to face various uncertainty and risk in production process (Mendola, 2007). So, other prominent theory related to technology adoption is considered as utility maximization theory.

According to this theory, the farm or households decision to adopt new agricultural technology is determined by using an expected utility model. This school of thought argues that smallholder farm households are not typical profit maximizers. This is because the households face imperfect markets and they have to make tradeoffs between purely economic and non-economic considerations. The adoption process is also found to be influenced by adopters' behaviour. According to the theory of planned behaviour and other studies such as Straub (2009), technology adoption is a socio-developmental process and behaviours of adopters determine actual use of the technology.

Numerous empirical technology adoption studies have been conducted over the last 50-60 years beginning with the work of Griliches (1957) and Rogers (1962). Feder et al. (1985), Pattanayak et al. (2003) and Prokopy et al. (2008) review many of agricultural adoption studies and major determinants of agricultural technology adoption.

There are various factors at macro and micro levels, which are expected to influence farmers' decision about the adoption of agricultural technology adoption (Paudel & Thapa, 2004; Knowler & Bradshaw, 2007; Nepal & Thapa, 2009). Socio-economic characteristics and institutional policy framework such as farm size, annual farm income, gender, access to information, distance from market centre, access to resources such as loans and agriculture extension services, perceived usefulness, ease of use of technology and ethnicity are considered as important factors and have significant effects on the decision-making process (Dorfman, 1996; Kaliba et al., 2000; Venkatesh et al., 2003;Paudel & Thapa, 2004; Joshi & Bauer, 2006; Knowler & Bradshaw, 2007; Paudel et al., 2008; Prokosy et al.., 2008; Nepal & Thapa, 2009; Westra & Hall, 2008) and technological attributes such as relative benefits and cost of technology (Rogers, 2003).

Technology adoption is about re-allocation of resources and decisions made at the household level in response to changing economic circumstances, which would allow farmers to take advantage of the opportunities provided by the introduction of new technologies. Since the development of the concept of human capital in the 1960s, scholars have argued that highly educated workers have a comparative advantage in dealing with economic change and uncertainties, thereby, increasing the allocative ability and reducing the risk that facilitate greater adoption of new technology (Shultz, 1964; Nelson & Phelps, 1966; Welch, 1970; Wozniak, 1984). Moreover, Nelson and Phelps (1966) suggest that the role of human capital or education in development is vital and they considered education may contribute beyond its role as a mere factor of production. But, potential or latent role of education has not been studied in a developing country context in a systematic way.

In Nepal, there is a dearth of knowledge to explain the adoption process and major factors for influencing adoption in agriculture. There are some sporadic evidences that show that farmers use their educational experience and there is a need to study its role in the technology adoption.

Current Status and Research Gap of Technology Adoption

The literature review shows that a considerable gap exists between potential farm yield and actual yield of different crops. The gap between potential and actual yields of rice, maize and wheat stand at 2.76, 2.58, and 3.15 metric tons per ha respectively in Nepal. There is also a big gap in crop varieties developed by researchers and the ones actually used by the farmers (Kaini, 2014). There are many reasons for low agricultural productivity and, among them, low adoption of technologies by farmers has been one of the main challenges.

Despite several efforts to promote technologies and possibility of fetching good returns from new technologies, those technologies are not being satisfactorily adopted as expected. In this backdrop, it is vital to understand the reasons for less adoption and identify the reasons that determine technology adoption in smallholding farming context in Nepal.

It is also important to explore the adoption process that is suitable for small farming context in Nepal. There are various adoption theories available. The existing adoption theories suggest that the adoption process is complex (Straub, 2009), but there is no clear explanation on what type of theoretical framework is appropriate in the Nepali context to understand the technology adoption process. It is also important to know whether farmers prefer profit maximization or they opt for utility maximization while selecting technologies. It is equally important to know the role of education in human capital formation and their impacts on technology adoption process. The literature review showed that formal education helps to assess risks, to increase efficiency and the allocative ability of farmers, but there is no systematic information available to know the relation of formal education and human capital in relation to the technology adoption process. All these questions are not adequately researched in Nepal to make evidence-based policy-making and programme planning in the agriculture sector.

Conceptual Framework of the Study

Based on the review of theoretical and empirical studies on the adoption of improved technology, the following conceptual frameworks have been developed to guide this study.

The adoption decision is undertaken only when the incentives outweigh the disincentives. Successful adoption and continued use of technology depends on farmers' perception of the incentives and disincentives provided along with those technologies. If perceived benefits are higher than the costs, farmers are motivated to adopt a technology as they expect high returns on investment. Hence, this study has adopted the Utility Maximization theory to analyse various types of determinants of technology adoption. Utility maximization is also determined by the behaviour of a person and knowledge she or he possesses. So, behavioural theories, i.e. the theory of Planned Behaviour (TPB) and Human Capital Theory (HCT) were also used to identify and explain the determining factors of technology adoption.

Based on the literature review, the study has considered various factors of adoption on two types of technology, i.e. embodied (improved rice variety) and disembodied (IPM). As the role of education was found to be important for increasing efficiency and allocative ability of farmers, the study has also considered assessing the role of education on two types of technology and the role of formal education on human capital theory.

The study treated adoption of improved rice varieties and IPM as the dependent variables, while the explanatory variables are farmers' socio-economic characteristics, their perception of the technology's characteristics, personal attributes and enabling environment. This can be represented as:

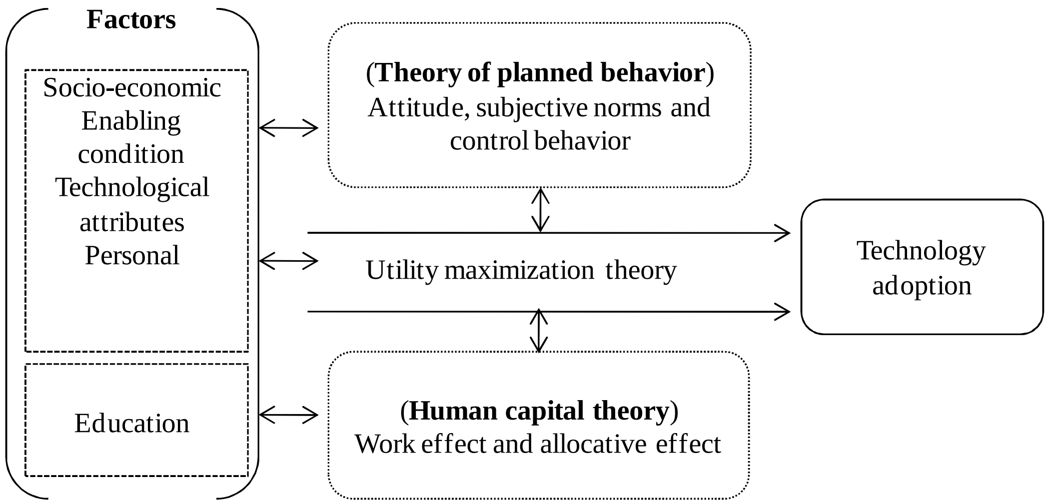
$$Y = \beta_0 + \beta_1 X_1 + \ldots + \beta_n X_n$$

Where, β_0 = constant/ intercept, $X_1 \ldots X_n$ = explanatory variables, $\beta_1 - \beta_n$= coefficient of explanatory variables

In this study, a farmer is defined as an adopter if he or she is found to be growing any improved rice variety and IPM in the last three years and non-adopter for otherwise. The adoption variable was, therefore, binary or dichotomous. However, the independent variables were both continuous and discrete. The study, therefore, adopted logistic regression to assess the factors that determine the farmers' adoption status as well as compare between adopters and non-adopters.

Utilizing this framework, the present study provides a rigorous empirical examination to understand how the agricultural technology adoption affects individual households' decision making process in the smallholding farming context (Figure 3).

Figure 3. Conceptual Framework for the Study



Essence of the Chapter

The review showed that the agriculture sector has been facing several challenges, the agriculture productivity trend is not satisfactory, and the sector is not able to meet the increasing national food demand. The annual growth rate in agriculture is very slow and contribution of agriculture on national economy (GDP) is also decreasing over the years. Subsistence based agriculture is still predominant in Nepal and existing policies and strategies are not able to adequately support small holding farming systems. The agriculture policies are found to be mostly top down and they have not contributed as expected in terms of increasing efficiency, promoting equity and ensuring food security. In addition, the policies and strategies were not able to pay required attention to generate appropriate technology and transferring those technologies for smallholding farmers. The link among research-education- extension was weak.

It has also come to light that new technologies such as improved rice varieties are more productive than local varieties, but their adoption rate is considerably low. This has led researchers and policy makers to investigate why some farmers ‘adopt’ and others ‘do not adopt’ agriculture technologies; what are the major determinants of adoption for various types of agriculture technologies; and which theoretical framework helps to explain the adoption process in small farming context.

Some adoption theories are useful to analyse the adoption process. The review showed that farmers prefer to choose multiple benefits (economic and non-economic) from new technologies; hence utility maximization theory can describe the adoption process in better ways. The utility maximization is influenced by behavioural process and so theory such as the theory of planned behaviour are useful to understand the process. As these theories posit that human being are rational while taking adoption decision, human capital development theory, therefore, helps to understand and explain the adoption process.

Considering all these contexts, rice production systems and theoretical underpinning, a conceptual framework was developed that helped to understand and explain the determinants of technology adoption. These factors are personal attributes, socio-economic status, attributes of technology and enabling environment at smallholding farming level.

CHAPTER III

RESEARCH METHODOLOGY

A cross-sectional survey research method was employed in this study. The research methodology and methods for this research were chosen based on the quantitative focused research purpose and research questions. The rationales of the chosen methodology are discussed. This chapter provides a brief account of research philosophy, research design, sampling framework, sampling process and data collection, data analysis, and data management. Justifications for using regression for binary dependent variables have been provided. The final section of this chapter presents reliability, validity and ethical considerations for this study and concludes with a summary of the chapter.

Research Philosophy

The selection of research methodology depends on the paradigm that guides the research activity; beliefs about the nature of reality and humanity (ontology); the theory of knowledge that informs the research (epistemology); and how that knowledge may be gained (methodology) (Tuli, 2010). The major research paradigms include positivism, post-positivism and constructivism and critical theory approach (Guba & Lincoln, 1994) and these paradigms have differences, especially in understanding the nature of reality and knowledge (Guba & Lincoln, 1994; Johnson & Onwuegbuzie, 2004;Feilzer, 2010;).

The positivist notion believes in a single reality, the one and only truth that are out there waiting to be discovered by objective and value-free inquiry (Feilzer, 2010). It believes that reality is an externality which exists independently of human thought and perception. It further assumes that social complexity can be explained and predicted by investigating causal relationships between the constituent elements. Post-positivists accept that researchers' theories, background, knowledge and values can influence what is observed. However, like positivists, post-positivists pursue objectivity by recognizing the possible effects of biases. So, they believe that a reality exists, like positivists do, though they hold that it can be known only imperfectly and probabilistically (Guba & Lincoln, 1994; and Johnson & Onwuegbuzie, 2004).

Non-positivist (including constructivism and critical theory approach) believes that reality is subjective, relativistic or self-referential, and non-material, and is, therefore, internally experienced, interpreted and constructed by the human. Within this paradigm the individual is unique and significant (idiographic) (Bisman, 2010). It rejects the idea that there is a single objective reality and favours subjective inquiry (Feilzer, 2010).

The quantitative paradigm, based on positivism or post-positivism, assumes that a researcher can study a phenomenon without influencing it or being influenced by it (Sale, Lohfed & Brazil, 2002). The goal of quantitative technique is to measure and analyse causal relationships between variables within a value-free framework (Johnson & Onwuegbuzie, 2004). According to this school of thought, educational researchers should eliminate their biases, remain emotionally detached and uninvolved with the objects of study, and test or empirically justify their stated hypotheses (Johnson & Onwuegbuzie, 2004). These world views help to identify an appropriate research design to this study.

In addition to these worldview, according to Creswell (2009) research problem (or issues being addressed / research questions) along with the personal experience of the researcher and the audience(s) for whom the report will be written determine the research design. He further mentioned if the problem calls for (a) the identification of the factors that influence an outcome, (b) the utility of an intervention, or (c) understanding the best predictor of outcomes, then a quantitative approach is best.

The research issues being addressed in this study were related to identification of independent variables that influence an outcome and also to know the best predictor of the outcome so, the research questions were developed to know the statistically significant variables for technology adoption. In order to answer the research questions, a survey research approach was employed in this study.

This approach provides an opportunity to remain detached with personal emotions, uninvolved with the object of the study and empirically justify the hypothesis (Johnson & Onwuegbuzie, 2004) to explore objective knowledge. Furthermore, the technique would also allow managing a number of variables that can be analysed using scientific methods. The numerical values derived from these processes then could be used for significance test analysis and test the hypothesis with ensuring the scientific rigour. Hence, this study used post-positivist as the main research paradigm and the research follows the objectivist (ontology), empiricist (epistemology) and quantitative approaches to answer the research questions.

Research Design

A causal survey research design was used for this study. The reason for the choice of this method was to describe the nature of the situations as it existed at the time of the survey. The main tool of measurement in this design was a structured questionnaire which collected objective and reliable numeric data. The co-relational procedures, such as descriptive statistics and logistic regression, are employed to determine the extent of relationship existing between variables and to compare adopters and non-adopters. The procedures also enable testing the hypothesis about the relationship between the dependent and explanatory variables as well as to assess the magnitude and direction of the relationship.

Surveys aim to collect information as accurately and precisely as possible and try to do this in such a way that if they were repeated at another time or in another area the results would be comparable (Bowling & Ebrahim, 2005). It can target a large sample at a relatively low cost and effort; it ensures that the same questions are asked of each respondent and it is easy for the participants to remain anonymous (McMillian & Schumacher, 2006).

The other advantage of the survey is that it is carried out in natural settings. This allows statistical inferences to be made in relation to the broader population of interest and thus allows generalizations to be made. This increases the external validity of the study (Bowling & Ebrahim, 2005). Hence, the survey questionnaire was found to be appropriate for this study.

Sampling Frame and Design

A clear and precise identification and definition of the population of the study is an important prerequisite for research sample design. This study defines the survey population of rice cultivating farmers (adopting or not adopting improved rice varieties and adopting and not adopting IPM) from two agro-ecological regions. For this, a multi-stage sampling method was employed. Through this process, two districts and six VDCs/municipalities were selected. The site selection criteria and processes are briefly discussed below.

Site Selection

The main criteria for selection of districts were: I) IPM implementation programme districts (by the government); ii) level of rice productivity; iii) possible accessibility of technology; and iv) ecological representation of rice cultivation. The following processes were adopted to select the districts.

- Area where farmers have better access to technology: The sub-criteria was related to the proximity of agriculture research institutions, academic and training institutions and government's focused programmes on agriculture and accessibility to physical infrastructure such as road and communication.
- Rice productivity and implementation of IPM programme: The proposed site should have rice productivity that is higher than the national average and national IPM activities already implemented through district agriculture development offices.
- Represent agro-ecological zones and rice production area: Nepal has three ecological zones, i.e. High hills, Mid-hills and Terai. Rice is predominantly cultivated in Terai and mid hills so that the two sites should represent these ecological zones.

Literature shows that access to knowledge and distance plays an important role in technology adoption (Sunding & Zilberman, 2001). For example, road and telephone connectivity also helps agricultural technology adoption (Sunding & Zilberman, 2001; Mittal & Tripathi, 2009).

Based on criterion 1, the analysis showed that the Central Development Region had more number of academic/vocational institutions (i.e. schools, colleges, agricultural universities, and agricultural colleges). Besides, central region also had strong road connection (40% of the roads in Nepal) and highest number of VDCs with at least one telephone (NTA, 2008).

Government of Nepal has been implementing a major IPM programme in 17 districts, which includes four districts from the Centre Development Region: Bara, Kavre, Chitwan and Dhading. Rice productivity in Dhading is less than the national average; so, this is excluded based on criterion 2. From criterion 3, there should be at least one district from two ecological regions. In terms of access, Chitwan has better knowledge access over Bara. So, selected site for the study were in Chitwan and Kavre districts.

Villages were selected based on abundance to rice cultivation and implementation of IPM in rice by the District Agriculture Development Offices (DADOs). This information was collected from the DADOs of Kavre and Chitwan in 2013. Based on these criteria, three VDCs from Kavre, viz. Mahadevsthan, Kusadevi and Rayale, and three VDCs/municipalities from Chitwan, viz. Mangalpur, Bhandara and Ratnanagar, were selected for the study.

Sample Size and Sampling Procedure

Salant and Dillman (1994) define sample as a set of respondents selected from a larger population for the purpose of a survey. To determine the sample size, different criteria are important. Level of precision, degree of variability and confidence level, budget (cost) and time are important factors for selecting sampling size (Bartlett, Kotrlik & Higgins, 2001).

According to Salant and Dillman (1994), the size of the sample is determined by four factors: (1) how much sampling error can be tolerated; (2) population size; (3) how varied the population is with respect to the characteristics of interest; and (4) the smallest subgroup within the sample for which estimates are needed. Appropriate sample size depends on various factors relating to the subject under investigation like the time aspect, the cost aspect, the degree of accuracy desired, etc. (Gupta & Gupta, 2002).

This study is based on the reference of sample size as proposed by previous research, research cost implications and representation of population. For this, some relevant journal articles were reviewed. Prokopy et al. (2008) reviews 55 technology adoption-related studies and their analysis in relation to sample size shown from a diverse range (40 to 27,337). Shakya and Filn (1985) studies adoption of modern varieties and fertilizer use in Nepal and took 177 samples. Joshi and Bauer (2006) studies farmers' choice of the modern rice varieties in the rain-fed ecosystem of Nepal and a total of 222 rice-growing farmers were randomly selected from these six VDCs of two districts. Adeogun, Ajana, Ayinla, Yarhere and Adeogun (2008) assess hybrid catfish in Nigeria and took 95 fish farmers.

The study considers the smallholder rice farming households who adopt IPM and do not adopt IPM. The following formula has been used (Krejcie and Morgan, 1970) to calculate the sample size:

$$s = X^2NP(1-P) \div d^2(N-1) + X^2P(1-P)$$

Where s = required sample size;

X^2=the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841);

N = the population size;

P = the population proportion (assumed to be about 0.80 as the access to technology, knowledge base (literacy rate) and social infrastructure are similar in Kavre and Chitwan);

d = the degree of accuracy expressed as a proportion (0.05).

The formula has been used by many researchers, including Halilovic & Cicic (2013), Ahimbisibwe and Nangoli (2012) and Martins & Meyer (2012) to identify the appropriate sample size.

Table 2

Sampling Design and Sample Numbers

Districts and sites	Study population (IPM groups)	Sampled population from the groups	Control (outside groups)	Total sampled households
Kavre: Mahadevsthan, Kusadevi and Rayale	250	130	130	260
Chitwan: Mangalpur, Ratnagar and Bandara	225	118	118	236
Total	475	248	248	496
Added during interview (for minimizing low response)		21	21	538

Based on this formula, sample size for 225 households in three VDCs/municipalities of Chitwan were 118 and in three VDCs of Kavre were 130 (Table2). In addition, to integrate technology adoption and potentially non-adopting farmers, additional 248 samples were selected from non-IPM farmers from the same area. So, the total samples were 496 which actually reached 538 while undertaking the survey. The households were chosen based on simple random sampling method. For this, list of households from each VDCs were collected from district level election office. Based on the lists, all serial no of households from each VDC were written in a small piece of paper which was then selected through lottery method.

Description of the Study Area

Kavre district is one of the hill districts of the Central Development Region. The population in 2011 in Kavre was 213,184 (CBS, 2012a). It lies between 27° 20' and 27° 45' north latitude and 85° 24' and 85° 49' east longitude. The total area of the district is 1,396 sq. km (1,40,486 ha) and the average elevation ranges from 300 m to 3,018 m above the mean sea level. Demographic situations are presented in Table 3.

The land data shows that 61,598 ha (44%) are total cultivable land. The total surface irrigated land was 7,950 ha, whereas year-round irrigated land was 5,137 ha. The data show that 43,798 ha of the land in district is un-irrigated. The total households in the studied VDCs in Kavre was 19,595 (i.e. Rayale 4,315, Mahadevstan 8,166, and Kushadevi 7,114) (CBS, 2012a). Among them, 275 households were found to be adopting IPM from the government-sponsored programme.

Table 3

Demographic Situation in Kavre and Chitwan Districts, 2011

S.N.	Description	Kavre	Chitwan
1.	Total population	381,937	579,984
2.	Total male population	182,936	279,087
3.	Total female population)	199,001	3000,897
4.	Total households (no.)	80,720	132,462
5.	Population density (no / square km)	274	261
6.	Annual population growth rate (no.)	-0.10	2.06
7.	Average family size (no.)	4.73	4.38
8.	Gender ratio (male in 100 female) (no.)	91.93	92.75
9.	Literacy rate (%)	60.92	70.68

Source: CBS, 2012a

Chitwan Valley is an inner Terai valley in the South of Nepal. The population in 2011 in Chitwan was 961,921 (CBS, 2012a). The Chitwan Valley is drained by the (East) *Rapti* River, which flows from the eastern *Mahabharat* Range into the valley near Hetauda, where it turns west and flows along the axis of the valley. The valley is part of the *Terai-Duar* savanna and grasslands eco-region of about 150 km length and 30–48 km width. Chitwan district covers an area of 2,250.9 square km and has a population of 579,984. The climate of Chitwan is sub-tropical monsoon type with hot and humid summer and cool and dry winter.

Over 75% of annual rainfall occurs during the monsoon from June through September and very low rainfall occurs from January to April with an annual average rainfall of 2,318 mm. Groundwater is sufficient to supply two important irrigation systems of Nepal: the Khageri Canal system and Narayani Lift System.

Agriculture makes up the most important productive sector in Chitwan Valley. In terms of area planted, value of sales, and as a staple food, rice is the most important crop in the Chitwan farming system, followed by maize and wheat. Originally, *Tharus*¸an indigenous ethnic group, in Chitwan produced dry rice varieties, whereas new settlers prefer wet rice cultivation. With increasing human pressures on arable land, the land use system was intensified. Improved technologies and extended irrigation facilities have increased cropping intensity and cereal grain production to an extent of three crops a year, depending on land quality.

Livestock keeping is still an integral part of crop agriculture. Oxen and buffalo used to be kept for draught power and production of manure and milk, but these relations are being changed due to change in the contexts that promote commercialization of agriculture. Poultry has become one of the important enterprises in recent years.

Chitwan is highly populated district compared to other districts in Nepal. *Tharus* are the indigenous communities and they have a history of more than 600 years that area. The district received a lot of migrants from the adjoining hilly districts after the government initiated a resettlement programme about 60 years ago. A brief demographic situation is presented in Table 3. The total number of households in the studied VDCs in Chitwan was 81,554 (i.e. Bhandara 16,121, Mangalpur 19,066, and Ratanagar MC, 46,367) households (CBS, 2012a). The households adopting IPM were 225 (DADO Chitwan, 2012).

Selected Variables and Adoption Model

Based on the potential contribution to rice productivity and overall agriculture development in Nepal, adoption of improved rice varieties (embodied) and IPM (disembodied) technologies by farmers in two districts were selected for this study. There were various technologies available in IPM such as insect and disease management and soil and fertility management, the study however considered economically important insects in the national IPM programmes of the government of Nepal. So, this study chose to limit management practices for major insects. In case of insects, there are many economically important insect and pest and this study considered rice *gundhi* bug (*Leptocorisa oratorio*) and yellow stem borer (*Scirpophaga incertulas*) of the study areas.

The literature review showed a wide array of determinants for adoption of rice technology. Chapter 2 provides detailed account of possible determinants that were responsible for agricultural technology adoption in Nepali farming systems. Previous studies carried out in Nepal and outside show that the role of education in technology adoption is generally influential (Nelson and Phelps, 1966; Lin, 1991; Dorfman, 1996;

Gillespie& Paudel, 2007; Paudel et al., 2008) in agriculture technology adoption process.

Similarly, socio-economic, institutional and technological factors such as age, ethnicity, gender, farm size, access to market, farm income, access to credit, access to extension services, role of the media, cost of technology, benefits from the technology and ease of use (Shakya &Flinn, 1985; Cotlear, 1986; Jones 1989; CIMMYT, 1992; Lin & Milon, 1993; Adesina & Baidu-Forson 1995; Dorfman, 1996; Ayuk, 1997; Floyd et al., 1999; Kaliba et al., 2000;Doss & Morris, 2001; Pattanayak et al., 2003; Joshi & Bauer, 2006;, Paudel et al., 2008; Prokosy et al., 2008) were also important. Based on the literature review and theoretical framework discussed above, the following explanatory variables were chosen for this study (Table 4).

Empirical model. The explanatory variables for assessing the determinants for improved rice variety were ethnicity, age, gender, formal education (year of school education), farm size (land size), on-farm contribution to annual family income, contribution of media, non-formal education (agricultural training), participation in local groups, access to agricultural credit, access to market, cost of technology, economic benefits, non-economic benefits (i.e. straw quality) and ease of use of the technology.

Similarly, the explanatory variables for adoption of IPM were ethnicity, age, gender, formal education (number of year of school education), farm size, on-farm contribution to annual family income, non-formal education (participation in IPM field demonstration activities), informal education (participation in groups), access to agricultural loan, access to extension services, cost of technology, perceived economic benefit, perceived non-economic benefit (impact on human health) and ease of use of the technology.

Table 4:

Definition of Variables and Reference for Logistic Regression

Variables	Data type/ reference	Definitions/description
Dependent variable		
Probability of adoption of improved variety or IPM (Yi) (IVAD)	Binary	Farmer adoption decision 1 if s/he is adopting and 0, otherwise
Independent variable		
Formal education	Continuous	Formal - Years of school education
Non-formal education	Binary (reference: no = 0)	Non-formal (training): participation in training in agriculture (from improved rice var.) and demonstration of IPM field school (No = 0, yes 1)
Informal education	Binary (reference: no = 0)	Participation in farmers agriculture groups (No = 0, yes 1)
Media	Binary (reference: no = 0)	Media (Radio and newspaper) influence (No = 0, yes 1)
Age	Continuous	Age of operators in years (who take main decision in the farm)
Ethnicity	Categorical (reference: BCTs = 0)	Social groups/caste, *Brahmin*/*Chettri*, Thakuri = 1, *janajati*/ethnic community= 2, *dalit* and other = 3)
Gender	Binary (reference: female = 0)	Female (0) and male (1)
Farm size	Continuous	Farm size, including all land types: area (*Kattha*)
Access to market	Ordinal (reference: less than 5 km = 0)	Distance to market (in Km) (less than 5 KM, =0, 5- 15 KM = 1 and more than more than 15 KM = 2)
On farm contribution to family income	Continuous	Percentage contribution of agriculture (crop, vegetable and livestock) on household income
Access to agricultural loan/credit	Binary (reference: no = 0)	Loan taken from the bank (yes = 1, no = 0)
Access to extension services	Binary (reference: no = 0)	No of meetings/visits with extension works (yes = 1, no = 0)
Cost of technology	Binary (reference: no = 0)	Price of technology: costly (yes = 1, no = 0)
Economic benefits	Binary (reference: no = 0)	Contribution on livelihoods improvement (yes = 1, no = 0)
Ease of use	Binary (reference: no = 0)	Easy to handle (yes = 1, no = 0)
Non-economic benefits: Straw quality and human health	Binary (reference: no = 0)	Quality and higher amount/ positive human health impact (yes = 1, no = 0)

Based on these selected explainatory variables following models were proposed for adoption of improved rice varieties and integrated pest managment (IPM). As the main purpose of the study is to identify the major determining factors for the two selected(emboided and disembodied) technologies, it is assumed that farmers take independent decision on the technology selection and adoption so two equations for two technologies are proposed.The model can be summarized as follows:

IRV adoption= $\beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \beta_{11}X_{11} + \beta_{12}X_{12} + \beta_{13}X_{13} + \beta_{14}X_{14} + \beta_{15}X_{15} + \varepsilon$……….…….................................i

Where β_0 = constant/ intercept, X_1 = ethnicity, X_2 = age,X_3 = Gender, X_4 = formal education, X_5 = Landsize, X_6 = On-farm contribution (crop, vegetable and livestock), X_7 =training in agriculture (non-formal education), X_8 =involvement in group (informal education), X_9 =contribution of media, X_{10} =Access to agricultural loan, X_{11} = Access to market (distance to district headquarter), X_{12}= Cost of technology (seed price), X_{13} = non-economic benefits (i.e. straw quality/amount),X_{14} = Ease of use of technology,X_{15} = Economic benefits from technology, and ε= random error term.

IPM adoption = $\beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \beta_{11}X_{11} + \beta_{12}X_{12} + \beta_{13}X_{13} + \beta_{14}X_{14} + \beta_{15}X_{15} + \varepsilon$……….…….................................ii

Where β_0 = constant/ intercept, X_1 = ethnicity,X_2 = age,X_3 = Gender, X_4 = formal education, X_5 =Land size, X_6 = On-farm contribution (crop, vegetable and livestock), X_7 =training in agriculture (non-formal education), X_8 = involvement in group (informal education), X_9 = Access to agricultural loan, X_{10}= Access to agricultural extension, X_{11}= Cost of technology (seed price), X_{12} = non-economic benefits (i.e. impact on human health),X_{13}= Ease of use of technology,X_{14}= Economic benefits from technology, and ε= random error term.

Data Collection

Data was collected by using a structured questionnaire (annex 1). Specific strategies were adopted to enhance the response rate in the design of the questionnaire. They included some easy-to-answer questions, kept in the first section to encourage participation and engaging curiosity; and the wordings of questions were simplified to enable the respondents to easily understand and answer them. Questions in the survey were developed and administered in Nepali Language.

Pre-testing of the questionnaire was conducted in March 2013 by interviewing the active rice with IPM farmers outside the project study sites. About 2.5% (20) of pre-testing was carried out in the research area. Pre-testing helped to get feedback on issues related to wordings, measurement and ambiguities in the questionnaires. After the pre-test, the questionnaire was revised based on the suggestions received.

Data collection took place from March to July 2013. Face-to-face interview was carried out by visiting farmers' houses or cropland as demanded by the context. Their views were documented in the questionnaire sheet. The first section was about general information and level of education. The second part was about socio-economic status of the farmers along with information on rice and IPM. The third component was about possible determinants of technology adoption and multiple choice questions were included. The last component was about their main interest in technology adoption in 'Likert' scale. To assess the attitude and perception of the farmers on various determinants, Likert scales (5 = fully agree, 4 = agree, 3 = neutral, 2 = disagree, 1 = fully disagree) were used.

Data Management

Statistical Package for the Social Sciences (SPSS) version 20 was used for data analysis. Data was coded by assigning character symbols. Each question or item in the questionnaire was given a unique variable name. During the data entry stage, data was edited by checking and adjusting for errors, omissions, legibility and consistency to ensure completeness, consistency, and readability of the data. In addition, other simple analysis, such as frequency distribution, checking minimum, maximum, mean and standard deviation, were also carried out.

Univariate outliers were analysed by using Mahalanob test. Mahalanob distance is the distance between a data point and a multivariate space's centroid (overall mean). The analysis showed that there were no outliers using a Z score more than plus and minus 3, except in total land size explanatory variables. This variable had 19 (out of 538) outliers (Z score more than 3) and those data were re-verified and found that they were true so the data were kept as such.

Multicollinearity occurs when one independent variable is highly correlated with another independent variable (Lewis-Beck, 1980). Since many of the variables used in social science research are related to one another conceptually, multi-co-linearity becomes a problem when conditions are extreme. The measure of association or co-relation of two explanatory variables was carried out for nominal and ordinal data by using Chi-square statistics. If the significance level is less than 0.05 then the relationship between two variables is considered significant. There were only two variables whose correlation to one another was statistically significant, so this variable (peer effect against group involvement) was taken out for further analysis.

In addition, multi-co-linearity was also checked by using standard error (SE) for the *beta* coefficients while carrying out logistic regression (see Yoo, Mayberry, Bae, Singh, He, & Lillard, 2014). A standard error greater than 2.0 indicates multi-co-linearity between the independent variables and the data analysis shows no multi-co-linearity. In this study, the logistic regression analysis showed that there were no standard errors more than 2 for the *beta* coefficients which suggest there was no issue of multi-co-linearity.

The data collected on the Likert scale were grouped into dichotomous form based on the responses received to use them for logistic regression. For example, in order to choose new rice varieties, straw quality and quantity of new varieties are important. The Likert scale data were converted to 1 and 2 scales for ‘yes’, and 4 and 5 scale for ‘no’.

Data Analysis and Synthesis

Data analysis was carried out in two stages. Initially, descriptive statistics such as minimum, maximum, frequency, mean, percentage and standard deviation were carried out. After that, inferential statistics, i.e. logistic regression (logit model), was used to establish relation and to identify the contribution/effects of independent variables to dependent variables and also to develop adoption models for the technologies. Greene (2003) suggests use of the logit model for binary outcomes (yes or no). The binary logistic regression was, therefore, chosen in this study to analyse the dependent variable (adoption of technology), which was in the form of yes (1) or no (0).

There are some distinct positive aspects of using logistic regression for this study. The binary logistic model does not make the assumption of linearity between dependent and independent variables and does not require normally distributed variables (Jera & Ajayi, 2008). In addition, the logit model is simpler to interpret and thus has been widely applied in adoption studies (Ngombe, Kalinda, Tembo & Kuntashula, 2014; Polson & Spencer, 1991).

This approach assumes that the dichotomous choice to adopt or not adopt rice technology (yes = 1; no = 0) can be represented by a logistic regression model. The probability of adoption is explained as follows (Jera & Ajayi, 2008):

Probability of adoption = $P_{(y=1)} = e\ \beta o + \beta_1 X_1 / 1 + e\ \beta o + \beta_1 X_1$ ……………iii

The logit transformation of the probability of adoption, $P(_{y=1})$ can be represented as follows:

$\text{Log}\ [P_{(y=1)} / 1 - P(_{y=1})] = \beta o + \beta_1 X_1$ ……………….…………………………….iv

Equation iii represents the logarithm of the odds of adoption of technology on the explanatory variables that were included in the model. Since the logit model is a non-linear model, the normal R^2 measure for goodness-of-fit is not valid. To determine the percentage of correct predictions, the predicted probability of adoption is calculated for each household and the prediction is compared with actual adoption decisions.

In this study, both multiple logistic regression methods were used for significance test of proposed hypothesis. Logistic regression calculates the probability of adoption over the probability of no adoption and the results of the analysis are in the form of an odds ratio or marginal effects. Using marginal effects is one way to interpret coefficients but the study used the odds ratio because of the ease of interpretation.

For explaining the odds ratio, the methods used by Szumilas (2010) was followed. According to him, an odds ratio (OR) is a measure of association between an exposure and an outcome. The OR represents the odds that an outcome will occur given a particular exposure, compared to the odds of the outcome occurring in the absence of that exposure. In logistic, the regression coefficient (*b*) is the estimated increase in the log odds of the outcome per unit increase in the value of the exposure.

Reliability, Validity and Research Ethics

The following section has provided how reliability and validity were ensured in the research. It also provides the ethical measures taken during the study.

Reliability

A reliability analysis was conducted to ensure that the measured concepts were adequate or reliable. Reliability refers to a measurement that supplies consistent results (Blumberg, Cooper & Schindler, 2005). Reliability of the measures used for this study was enhanced several ways. Two strategies were used in this study to ensure reliability. They were consistent measurement of the concepts (Fowler, 2002) and data of internal consistency measurement (Downs & Black, 1998; Charter, 2007).

The first aspect was the consistent measurement of the concepts under investigation. For this, the research provided each respondent with an identical survey questionnaire for data collection. In addition, each survey instrument included clear and consistent directions for completing survey items and this information was written in a language easy to understand. Finally, response categories for the survey items were easy to comprehend and easy to complete.

The second one is about data internal consistency measurement. The mostly used internal consistency measure for dichotomous data is KR 20 (Downs & Black, 1998; Charter, 2007; Thompson, 2010). The KR20 for dichotomous responses are estimates based upon a single administration of a test assumed to have homogeneous items. These coefficients are intended to be an estimate of the test's reliability with respect to a single attribute postulated to underlie all the test items. For KR 20, above

0.6 is considered acceptable and above 0.7 good (Streiner, 2003). In this analysis, independent variables were used for reliability test, whereas other factual data such as age, ethnicity and gender were not used for the analysis. The KR 20 analysis showed that the KR 20 score for the study is 0.75; so, it was considered that the data are reliable.

Validity

Validity refers to the accuracy or correctness of measurement. There are basically three important validity issues for this study. They are internal validity, external validity and construct validity.

Construct validity is theoretically and philosophically concerned with whether or not survey questions measure the constructs intended for measurement. For this study, the concern was whether the survey was measuring farmers' responses to adopting technology or some other hypothetical construct. There are some threats to validity in this context. They are respondents may not understand a question. Sometimes, it is difficult to choose the priority and major determining factors as this has to pass through a cognitive thought process. For this, questions were simplified and when necessary examples were given. In some cases, farmers may not remember enough about what is being asked to provide an accurate answer and often have difficulty recalling information about events that happened in the past (Fowler, 2002). Thus, they were asked to provide information about events that occurred within a particular timeframe.

In addition, the research was designed to reduce survey error. According to Dillman (2007), there are four sources of error that concern researchers when gathering data from surveys. These sources of error are related to sampling, coverage, measurement, and non-response. Sampling and coverage error occur when the completed sample does not adequately represent the sample population and sites. The research carried out an unbiased – multi-stage sampling method to avoid such errors. In the beginning, two districts and MC/VDCs were selected based on pre-determined criteria, whereas household samples are based on random sampling.

Measurement error occurs when survey questions do not accurately measure the concepts they are intended to measure and generally result from poor question wording and poor survey construction. In this research, the survey questionnaire did not allow for adjustments to be made to the data collection instrument once it was distributed. But, in case of sensitive issues, they were granted anonymity in exchange for sharing their information. Error from non-response is another issue. Such error results from individuals who either do not complete the survey form or questions are not relevant to them. To avoid this situation, user-friendly questionnaires were prepared and suitable environment was created during interviews.

Internal validity refers to the extent to which it is possible to make an inference or causal claim that the independent variable is truly influencing the dependent variable. For this, a lot of literature review was done to see the links between various variables, pre-test was carried out and experts were consulted.

External validity refers to possible problems of generalizability of the study's findings to the population. The study followed the scientific sample design based on the random sample approach; so, external validity is also maintained in the study.

Research Ethics

The study followed the standard protocol of PhD research, including ethical issues and other considerations. Ethical behaviour pervades each step of the research process, including data collection, data analysis and synthesis. This research has been conducted considering ethical responsibility in accordance with the general principles of research ethics. These principles, by Ticehurst and Veal (2000), concluded that (1) no harm should occur to the research subjects (2) subjects should take part freely and (3) participation is based on informed consent.

This study has considered various aspects of ethical consideration such as mutual respect, non-coercion, follow democratic value and belief. One of the primary responsibilities of the research was treating the information given by the respondents as strictly confidential and guarding their privacy. They were told how this information would be used. The research team explained the objective of the study to respondents before conducting the survey. In addition, there was flexibility in answering the questions. There was no requirement for all of the questions to be answered. These aspects were also clearly written in the questionnaire set. Many efforts were given to effectively get the information without taking their much time so farmers were visited in their houses and cropland. Data were used in a responsible way and no mis-representation or distortion in the data was made.

Essence of the Chapter

This chapter provides detailed account of research methodology and ethical issues for research. In the beginning, research philosophy is discussed and provides some justifications why quantitative research based on post-positivist research paradigm was selected. Then, the chapter also provides the detailed process of sampling framework and sampling methods. The process for multi-stage sampling and household sampling methods is described. The chapter provides the detailed process of data collection, management and analysis is provided. Reasons for selecting statistical tools such as regression have been provided to test the hypotheses proposed in the research. The chapter has also provided some evidence how reliability is maintained through consistent measurement of the concepts, maintaining reliability of scale and measuring data internal consistency. Similarly, the chapter also provides some processes to maintain construct, internal and external validity. Finally, a brief summary has been provided on research ethics that were considered during the research.

CHAPTER IV

DETERMINANTS OF AGRICULTURAL TECHNOLOGY ADOPTION

This chapter presents results of the major determining factors of agricultural technology in the study sites by using data from the questionnaire survey. The chapter summarizes respondents' characteristics and compares characteristics of adopters and non-adopter by using descriptive statistics. The chapter presents the findings according to the research questions. The chapter provides the direction and degree of association of independent variables with the selected agricultural technologies. Finally, the chapter provides the contribution of formal education to farmers' human capital formation.

Characteristics of Respondents

The results of the study were based on the data collected from 538 households (248 from Chitwan and 290 from Kavre). The study was conducted in Kavre district (three VDCs, viz. Rayale, Mahadevsthan and Kushadevi) and Chitwan District (2 VDCs, viz. Mangalpur and Bhandara and 1 municipality, viz. Ratnanagar). The characteristics of respondents are briefly described below and specific information is provided in Table 5.

It was found that the respondents' age varied from 16 to 85 years. The average mean year of respondents was 43 years with standard deviation of 13 years. The average number of family size was 6 persons per household, whereas family size in Chitwan (5.5 person per household) was slightly less compared to Kavre (5.8 person per household).

The average farm size per household was 0.49 ha ranging from 0.03 ha to 2.37 ha (standard deviation 0.35 ha). It was found that the average farm size in Chitwan was smaller (0.45 ha or 13.32 *Kattha* with 11 standard deviation) compared to Kavre (0.53 ha or 15.76 *Kattha* with 6.47 standard deviation). About 59% of people had less than 0.5 ha of land and another 40% of farmers had land size from 0.5 to 2 ha, whereas about 1% of farmers had more than 2 ha of land. This statistics is also in line with the national data. According to CBS (2013b), farming households with less than 0.5 ha of land comprise 45% and with less than 1 ha of farm size comprise 67.2%. So, it was found that most of the farmers were smallholding farmers in the studied districts.

The level of education of respondents varied from illiterate to higher degree. The average number of years of school of the respondents was 5 years, which means farmers on an average attended up to class 5. At district level, respondents in Chitwan (5.96 years) had more years of education than in Kavre (4.6 years).

The data analysis also shows that about 51% of the people were either illiterate or attended primary school (up to class 5), 44% attended secondary school (up to class 12) and only about 5% attended higher education. The education level among the sampled households was found to be higher compared to national average. CBS (2013b) shows that household heads from about 72%, 26% and 2% of households in Nepal had class five or less, secondary and higher education respectively.

It was also found that respondents with higher farm size spend more years for formal education. For instance, more than 50 per cent (52%) of small farmers (< 0.5 ha) attended primary education, whereas only 2 per cent attended higher education, whereas in case of big farmers (> 2 ha), 18% attended higher education. Table 5 shows the mean and standard deviation of age, education, farm size and family number of the respondents.

Table 5

Characteristics of Respondents

Research sites	Statistics	Age of respondents (year)	Education of respondents (year)	Farm size (ha)	No of family members (no)
Overall	Mean	43.37	5.22	0.49	5.65
	SD	13.337	4.7	0.35	2.4
Chitwan	Mean	43.02	5.96	0.45	5.51
	SD	13.825	4.687	0.37	2.4
Kavre	Mean	43.67	4.60	0.53	5.77
	SD	12.921	4.748	0.32	2.4

Source: Field Survey (2015)

Out of total respondents, about 73% (394) were from *Brahmin, Chhetri* and *Thakuri* communities, whereas *Janajati* (e.g. *Gurung, Magar, Tharu, darai, Newar, Rai*) and *Dalits* (*Kami, Damai and Sarki*) including *Muslim* represented 25.5% (137) and 1.1% (6) respectively. Among *Janajati*, about 13% were from hill *Janajati* (mainly *Magar, Gurung, Newar and Rai*) and about 12% were from *Terai* indigenous communities (*Tharu and Darai*).It is however noted that higher number of ethnic community participated in Chitwan district. The recent national population census, however, shows that *Brahmin and Chhetris* constitute only about 29% of Nepal's population (CBS, 2012b).

In case of gender, more or less equal number of male (51.9%) and female (49.1%) were interviewed in both districts. The participation of women in Chitwan was less (48%) compared to Kavre (50%) (Table 6).

For the adoption of new variety rice, about 70% of the respondents mentioned that they were the main persons to take decision at household level. Farmers were, however, found to be supported by their family members in their household level decision making process. For example, 76% of the respondents reported that they received support in technology adoption process from their spouses, followed by father (9%) and son (9%).

Table 6

Characteristics of Respondents (Ethnicity and Gender)

Explanatory	Chitwan		Kavre		Total	
variables	No	Percentage	No	percentage	No	percentage
Ethnicity						
Brahmin, Chhetri and Thakuri	163	65.7	231	79.7	394	73.2
Janajatis	79	31.9	58	20	137	25.5
Dalit and others	6	2.4	0	0	6	1.1
Total	248	100	289	100	537	99.8
Gender						
Female	119	48	145	50	264	49.1
Male	129	52	145	50	274	50.9
Total	248	100	290	100	538	100

Source: Field Survey (2015)

The analysis also showed that rice was the high priority crop. About 65% of the farmers mentioned that rice was their first prioritized crop, followed by vegetable (46%) and maize (46%). It was found that various types of rice varieties were used in the studied districts. In Chitwan, the predominant rice varieties were *Gorakhanath*, *Hardinath*, *Radha – 4* and *Sabitri*, whereas in Kavre, *Makwanpur* 1, *Mansuli* and *Khumal – 4* were common. Regarding the sources of seeds, in last five years, about 77% of farmers who adopted the varieties had used new varieties from outside (either from their relatives, neighbours or market). The data showed that about 11% farmers in Chitwan used hybrid seeds and they included *Garima, Mahima, Shankar, Prithivi* and *Vaishali*. In Kavre, there was very less use (about 1.3% of farmers) of hybrid rice.

Characteristics of Adopters and Non-adopters

In the case of improved rice varieties, there were 417 adopters and the remaining 120 were non-adopters, whereas in case of IPM, the total number of adopters were 271 and 266 were non adaptors. In Chitwan, about 83% of farmers were found to be adopting improved rice varieties, whereas in Kavre they were 73% of farmers adopting new rice varieties.

Some differences were noticed in the characteristics of the adopter and non-adopters. For example, in the case of improved rice variety adoption, the age is highly varied among the adopter and non-adopter. The average age of the adopters was 41 years with a standard deviation of 13 years, whereas in the case of non-adopters it was 51 years with a standard deviation of 12 years. But the family numbers per household have remained more or less the same (adopter - 5.63 and non-adopter - 5.72 members).

In the case of average number of years of school education, there was also a considerable difference. Adopters have 5.97 (with a standard deviation of 4.7) years of education where non-adopter 2.67 (with a standard deviation of 3.8) years. Some differences were also found in the education of the spouses of the respondents.

Spouses of adopters had 5.35 years of education, whereas non-adopters had 3.72 years of education.

The adopters generally had greater land size (average 0.52 ha per households with 0.36 SD) compared to non-adopters (average 0.41 with 0.28 SD). Similarly, size of land under rice cultivation was also found slightly different. In the case of adopters, the rice cultivation area was 0.31 ha per household, whereas in the case of non-adopter it was 0.21 ha.

Ethnicity and gender data showed that *Brahmin, Chhetri and Thakuri* (BCTs) and women were more progressive in the technology adoption process. About 80% (336) of farmers, who adopted new rice varieties, thought they were innovative and had positive attitudes toward new technologies, whereas in the case of non-adopters only about 8% people thought they were innovative.

The t-test analysis was also carried out to identify whether there was statistical differences among the adopter and non-adopter. The data analysis shows that adopter and non-adopters were significantly different (sig t-tailed p value < 0.05) in the case of age, education, gender and land size.

In case of IPM, there was difference in age. The average number of years of adopter was 38 (with a standard deviation of 12.43) years, whereas for non-adopters it was about 48 (with a standard deviation of 12.39) years. It was found that family size was slightly less in adopters (5.17 with a standard deviation of 2) compared to non-adopters (6.14 with a standard deviation of 2.72).

Differences in formal education both for respondents and their spouses were also noted. In the case of adopters, the average number of years of school education was found to be 6.25 and 6 of the respondents and their spouses respectively, whereas in the case of non-adopters it was 3.76 and 4 years for respondents and their spouses respectively.

Table 7

Major Characteristics of Adopter and Non-adopters

Characteristics	IRV		IPM	
	no adoption	Adoption	no adoption	Adoption
Age of respondent (mean year)	51	41	48	38
Education of respondent (mean year of education)	2.67	5.97	3.76	6.25
Education of respondent's spouse (mean year of education)	3.72	5.35	4	6
Ethnicity (percentage)				
Brahmin, Chhetri, Thakuri (BCT) (total 394)	20.5%	79.5%	43%	57%
Janajati (total 136)	27%	73%	68%	32%
Dalit and others (total 6)	33%	67%	50%	50%
Gender (percentage)				
Female (total 264)	16.6%	83.7%	28.8%	71.2%
Male (total 273)	27.8%	72. %2	69.5%	30.5%
Total number of family members at home	5.72	5.63	6.14	5.17
total land of the respondents (mean in hectare per hhs)	0.41	0.52	0.53	0.46
Total rice land (hectare per hhs)	0.21	0.31	0.03	0.28

Source: Field Survey (2015)

In case of land size, adopters had less farm size (0.45 ha with 0.33 standard deviation) as compared to non-adopters (0.53 ha with 0.36 standard deviation) which was the opposite with adoption of improved rice variety. Ethnicity and gender participation data showed that the BCTs and female are more innovative in the IPM technology adoption. In case of innovativeness, about 80% of adopters (209) thought they were innovative and positive toward new technologies, whereas 50% of non-adopters (135) thought they were also positive toward new technologies.

The t-test analysis was also carried out to see whether there was a difference among the adopters and non-adopters. The data analysis shows that adopters and non-adopters are significantly different (sig t-tailed p value < 0.05) in the case of age, education, ethnicity and gender. The differences between adopters and non-adopters are briefly presented in Table 7.

In summary, the analysis showed that in most of the demographic and socio-economic attributes, there were differences in attributes of adopters and non-adopters for both types of technologies.

Major Determinants of Technology Adoption

The main objective of the study was to better understand the agricultural technology adoption process and to identify major determining factors for agricultural technology adoption at the household level in the selected study sites. By referencing two agriculture technologies, i.e. embodied (improve rice varieties) and disembodied (integrated pest management), the study assessed major determinants, i.e. socio-economic variables, individual attributes, technological attributes and enabling factors of technology adoption.

The first research question assessed the level of contribution of education; the second research question identified adoption factors from socio-economic, personal and technological attributes, whereas the third research question explored the role of education in enhancing human capital by considering the human capital construct proposed by Welch (1970).

For this analysis, household survey data were used to identify statistically significant variables for improved rice variety and IPM by using logistic regression method. Multiple regressions were carried out between explanatory variables and dependent variables. A multiple regression analysis provided results for the combined influence of all explanatory variables on the dependent variable (DV) as well as the individual level of influence of each explanatory variable while controlling for the other explanatory variables. The simple regression coefficients between the variables and technology adoption are likely to be confounded by the unobserved factors that correlate with other variables, so multiple regression was used.

The results of the multiple regression of the research sites (the combined value of two districts) and two selected districts for both embodied (IRV) and disembodied (IPM) are presented in Annex 3, whereas Tables 8and 9 show the coefficient value, significance level and exponential of the coefficient (EoC) of the statistically significant explanatory variables. Detail descriptive data are presented in Annex 2.

The multivariate regressions provide the relative strength and direction of the independent variables for outcome variables. In the Tables 8and 9 below, *B* (beta) is the coefficient for the constant (or intercept) in the null model. The Wald test is used to determine statistical significance for each of the independent variables. The statistical significance of the test is found in the 'Sig.' column in the tables. Null hypothesis is rejected if the p-value (listed in the column called 'Sig.') is smaller than the alpha level 0 .05 (significance level). Exp (β)is the exponentiation of the β coefficient, which is an odds ratio. This value is given by default because an odds-ratio can be easier to interpret than the coefficient, which is in log-odds units. The findings from multiple regression analysis for the embodied technology (IRV) are presented in Table 8.

Table 8

Regression Analysis of Statistically Significant Variables for IRV

Explanatory variables	β	Sig.	Exp (β)
Ethnicity (*BCT*)		.651	
Ethnicity (*Janajati*)	-.111	.731	.895
Ethnicity (*dalit* + others)	-.870	.372	.419
Age of the respondents	-.038	.003*	.963
Gender (male)	-.345	.264	.708
Education of respondents	.089	.012*	1.09
Land size (in *Kattha*)	.040	.013*	1.04
On farm contribution to family income	.002	.711	1.002
Non-formal education (training in agriculture)	-.281	.388	.755
Informal education (farmers participation in groups)	1.18	.000*	3.26
Contribution of media	-.091	.772	.913
Access to loan	.010	.976	1.010
Access to market (distance to market)	-.425	.144	.654
Cost of technology (seed price)	-.221	.412	.802
Non-economic benefits e.g. straw	1.13	.000*	3.09
Easy to use of technology (easy to grow and manage)	-.909	.058	.403
Economic benefits (improvement on livelihoods)	1.28	.000*	3.60
Constant	.634	.545	1.886

** Significant variables*

For the research area, the logistic regression model was statistically significant, Chi-square (χ^2 (16) = 137.231, $p < .0005$. The model explained 36.3.0% (Nagelkerke, R^2) of the variance in technology adoption.

The findings from multiple regression analysis for the disembodied technology (IPM) are presented in Table 9.

Table 9

Regression Analysis of Independent Variables for IPM

Explanatory variables	*β*	Sig.	Exp (*β*)
Ethnicity (*janajati*)	-1.576	.008*	.207
Age of the respondent	-.037	.084	.964
Gender(men)	-1.481	.009*	.227
Education of respondents	-.020	.747	.980
Land size (in *Kattha*)	-.022	.304	.978
On farm contribution to family income	.013	.308	1.013
Non-formal education (field demonstration)	1.671	.001*	5.315
Informal education (farmers participation in groups)	1.163	.020*	3.200
Access to loan	.336	.574	1.400
Access to agri extension	1.325	.014*	3.763
Cost of technology	-.349	.490	.706
Perceived non-economic benefits (health impact)	2.119	.000*	8.320
Easy to use of technology (easy to grow and manage)	1.064	.065	2.898
Economic benefits (improvement on livelihoods)	.165	.758	1.179
Constant	-.049	.978	.952

** Significant variables*

For research site, the logistic regression model was statistically significant, Chi-square (χ^2 (14) = 149.879.168; $p < .0005$. The model explained 67.7% (Nagelkerke, R^2) of the variance in technology adoption.

Based on the multiple regression analysis, some regression models are developed for IRV and IPM technology adoption. The multiple regression generated adoption model is presented in Annex 4.

The main objective of the study was to explore independent variables for technology adoption, but it is also important to know why people do not adopt new technologies and still cultivate traditional varieties. It was found that about 22% farmers still grow local varieties, in the research area. Farmers, who did not adopt the new varieties and continued traditional varieties, were interested in continuing the use of local varieties (non-adopters) because the varieties were best suited with the local conditions and environment (57%) and provided better taste, scents and other benefits (50%) such as quality and quantity of rice straw. In addition, about 40% of people mentioned that they had less information on the new varieties.

Similarly, the main reasons for no adoption of IPM were: the technologies are not effective immediately (29%) compared to chemical pesticides, need a community approach to their implementation (19%), required a tedious process for their implementation (17%), and there were no premium prices for IPM products (12%) and require additional technical/practical knowledge (10%).

Education and Technology Adoption

The first research question was to explore the significance and level of contribution of education (formal, non-formal and informal through participation in group) on adoption of improved rice varieties and IPM technologies at household level. The specific research question was: to what extent does education have an effect on the selected technology adoption?

The significance and level of contribution of three types of education were analysed using data derived from multiple logistic regression (Tables 8 and 9, Annex 5). The odds ratios of statistically significant variables were analysed.

For this research questions, the hypothesis was: formal education, non-formal education and informal education from group participation have an effect on the agricultural technology adoption for both embodied and disembodied technologies.

Embodied Technology (IRV)

Based on the logistic regression analysis, the following sections provide significance and level of contribution of formal, non-formal and informal education through group participation in improved rice varieties such as *Radha 4, Radha 9, Khumal*, and *Sabitri* in the research area and the two districts (Tables 8).

Formal education. It is hypothesized that the farmer who have higher formal education are more likely to facilitate adopting agricultural technology by farmers. It revealed that the technology adoption rate was greater in the case of the farmers with higher formal education.

In the research sites, the multiple regression analysis showed formal education was highly significant (p=0.012) with Exponential of Coefficient (EoC) 1.093 for improved rice variety adoption (Table 8). An EoC of more than 1 means that with one year's increase in formal education, there is likely to be observed an increase in the adoption of improved rice variety by 9.3% among the farmers.

The contribution of formal education to technology adoption was significant (p = 0.007; EoC = 1.237) in Chitwan and this showed that with one year of increase in formal education, there was likely to increase the adoption of improved rice variety by

23.7% among the farmers in Chitwan (Annex 4). In the case of Kavre, although the relation is not significant (p = 0.333), there was, however, the possibility of increasing adoption by 4% (EoC of β = 1.041) with an increase in one year of education of a farmer.

The analysis was also carried out by categorizing formal education of respondents into primary (up to 5 class), secondary (6- 12 class) and higher education (more than 12 class). The multiple regression of education categories with improved rice varieties showed that secondary level education was significant (p=0.038) with the primary level of education. The regression analysis showed that odds of adopting improved rice variety by respondents with secondary education are 1.876 times the odds of respondents with primary education. This means farmers with secondary education are 1.87 times (or 87%) more like to adopt new technology compared to respondents with primary education.

The analysis showed the positive and statistically significant contribution of formal education in technology adoption of embodied technology (IRV). So, the finding of this study supported the proposed hypothesis.

Non-formal education. It is hypothesized that the farmers who have higher non-formal education are more likely to adopt technology. But in this study, the general training (on agriculture seed and general crop production) did not have any influence on improving rice variety adoption in the research sites (p= 0.383), Kavre (p = 0.503) and Chitwan (p= 0.266). So, the general hypothesis that non-formal education influences the adoption of embodied technology did not support in this case.

Informal education through group participation. Traditionally, farmers have been involved in social networks, community groups and farmer-to-farmer information sharing, which is considered as part of informal education. The general hypothesis is that informal education (participation through local groups) plays a positive role in technology adoption among farmers who have better informal education than those without informal education.

From multiple logistic regression analysis, it was found that informal education through participation in groups was highly significant (p=0.000) with EoC value of 3.268 (Table 8). At the district level, involvement of groups or informal education through participation in groups was highly significant in both Kavre (p=0.001, EoC = 4.19) and Chitwan (p=0.004, EoC = 5.591) (Annex 4).

The analysis showed that the odds of the respondents involved in groups or having informal education to adopt improved rice varieties were 3.26 times the odds for the respondents without involvement in informal groups at community level in the research area. In case of Kavre and Chitwan, the odds of adopting technology for those who were involvement informal groups were 4.19 and 5.6 times respectively the odds for those who did not have informal education. The district-level analysis also showed that informal education or involving in informal group played greater role in technology adoption. So, the findings of this study supported the proposed hypothesis.

Disembodied Technology (IPM)

Based on logistic regression analysis as shown in Table 9 and Annex 5, the following sections provide significance and level of contribution of all three types of education i.e. formal, non-formal and informal education on IPM adoption in the research area and the two districts.

Formal education. It is hypothesized that the farmers who have higher formal education are more likely to adopt technology. But, in the case of IPM, the role of formal education was not significant in the research sites (p = 0.747), Kavre (p= 0.188) and Chitwan (p = 0.286). So, the general hypothesis that formal education contributes to disembodied agricultural technology adoption did not support in this case.

Non-formal education. It is hypothesized that the farmers who have higher non-formal education are more likely to adopt technology. Non-formal education was found to be a significant contributor in adopting IPM technology in the research sites (p = 0.001): Kavre (p= 0.012) and Chitwan (p = 0.018).

Overall, the data showed that that the odds of adopting technology for farmers with non-formal education (farmers who participated in IPM field demonstration) were 5.3 times than for those who did not participate in IPM field demonstration (Table 9). Likewise, in Kavre and Chitwan, the odds of adopting technology for farmers who had non-formal education (farmers who participated in IPM) field demonstration were 13 and 5.7 times those who did not have non-formal education (Annex 4). So the hypothesis that non-formal education contributes to adoption of agricultural technology was supported by the findings of the study.

Informal education through group participation. The general hypothesis is that Informal education through group participation plays a positive role in technology adoption among the farmers who have better informal education than those without informal education. Informal education was found to be significant in the research sites (p = 0.020) and in Chitwan (p = 0.039), whereas it was not significant in Kavre (p = 0.257).

Overall, the odds of adoption for farmers with informal education through participation of local groups were 3.2 times the odds for farmers with no involvement in groups (Table 9).

In case of Kavre and Chitwan, the data showed that the odds of technology adoption for farmers with informal groups association were 2.57 and 4.77 times the odds for farmers without association of informal groups (Annex 5). So, the hypothesis that informal education (through group participation) contributes to agricultural technology was found to be supported in general by the findings of the study, but it can vary based on the farming context.

Major Findings

In the case of embodied technology, the analysis found that formal education and informal education through participation of local groups were statistically significant, whereas in the case of disembodied technology (IPM), non-formal education and informal education were found to be statistically significant.

Socio-economic, Technological, Enabling and Personal Attributes and Technology Adoption

The second research question was to assess the significance and level of contribution of socio-economic characteristics, personal attributes of innovators, technological attributes and enabling/environmental factors on adoption of embodied and disembodied technologies. The specific research question was: to what extent do socio-economic, enabling environment and technological characteristics affect technology adoption?

The significance and level of contribution of these variables were analysed by using the data derived from multiple logistic regression (Table 8, Table 9, and Annex 5).

For this research question, the hypothesis was: The selected explanatory variables from socio-economic, personal and technological categories affect embodied and disembodied agricultural technology adoption.

Embodied Technology (IRV)

Based on the logistic regression analysis (Table 8, Annex 5), the following sections provide significance and the level of contribution of ethnicity, age, gender, farm size, farm income, media contribution, agriculture loan, market distance, seed price, economic benefits, non-economic benefits and ease of use of technologies in IRV (such as *Radha- 4, Radha-9, Khumal, Sabitri*) in the research area.

Ethnicity. It is hypothesized that ethnicity influences technology adoption. In this case, *Brahmin, Chhetri* and *Thakuri* (BCTs) were selected as reference groups for regression analysis. The study found ethnicity was not significant in overall study sites (p = 0.651) and district (Kavre, p = 0.614 and Chitwan, p = 0.132) as well. So, in general, the hypothesis that ethnicity determines technology adoption was not supportive in this case.

Age. Age is said to be a primary latent characteristic in adoption decisions and this is thought to negatively affect the agricultural technology adoption process. The study found that age is negatively correlated with adoption. This indicated that an increase in age is likely to reduce technology adoption.

Ages of the male and female heads of household were measured. The exact age (years) was recorded for each household head. The age was statistically highly significant in the research sites (p=0.003) and Kavre (p = 0.003), whereas in Chitwan this was not the case (p = 0.100).

Overall, the relation of age with technology adoption was found negative (B = –0.038). The odds ratio showed that a year increase in age, there was decrease of probability of adoption of new technology. In the research area and Kavre district, the odds of adoption of IRV were 4% (EoC 0.961) and 5% (EoC = 0.948) lower respectively with one year of increase in age. Although the relation between age and adoption was not significant in Chitwan, it was found to be negative (b = -0.041).

These results showed that the proposed hypothesis received strong support. This means increase in age reduces the chance of technology adoption.

Gender. It is hypothesized that gender does not influence technology adoption as technology adoption is a household-level decision. The study found that gender was not significant (p = 0.264) in technology adoption in general. In case of districts, gender was significant in Chitwan (p = 0.014), however.

It shows that men in Chitwan were less receptive than women. The odds of adopting IRV were 79% (EoC 0.212) lower for men than for women holding other explanatory variables fixed. The analysis showed that women were more progressive in adopting new technologies than men. Although the variable is significant in Chitwan, in general, the a priori hypothesis was not supported by the finding of the study.

Farm size. It is hypothesized that farm size is positively related to agricultural technology adoption. It was found in the study that farm size is positive and significantly contributed to IRV adoption (p = 0.013). In case of district-level analysis, farm size was highly significant in Chitwan (p=0.000), whereas in Kavre it was not significant (p= 0.158).

The data analysis showed that the odds of adopting IRV with increase in one *Kattha* of land in research sites and Chitwan are 4% and 25% higher respectively. In general, it showed the hypothesis was supported in case of improved rice varieties.

On-farm income. On-farm income is generally considered as a positive factor that may influence technology adoption. The data analysis showed that the variable was not statistically significant in the research sites (p=0.711), Kavre (p=0.158) and Chitwan (p = 183), for both types of technology. Hence, the general hypothesis that on-farm income promotes to higher level of technology adoption was not supported in this study.

Media contribution. It is generally hypothesized that various forms of media contribute to technology adoption. In this case, the role of media was not found significant in the research sites (p = 0.772), Kavre (p = 0.171) and Chitwan (p = 0.883). Hence, general hypothesis that media promotes to more technology adoption was not supported by the finding of the study.

Access to resources – agricultural loan. It was considered that access to agricultural loan can influence technology adoption. Generally, farmers face shortages of cash partly due to low agriculture output price and increasing external input prices makes availability of agriculture loan to be an important determinant of farmers' adoption of technology adoption.

This study considered the formal loan from the bank or micro-finance institutions. The regression analysis however showed that there was no significant influence in the research sites (p = 0.976), Kavre (p = 0.070) and Chitwan (p = 0.465) from agriculture loan in technology adoption. Hence, the hypothesis that availability of agricultural loan promotes technology adoption was not supported in this case.

Access to resources - distance to market. It is generally hypothesized that longer distance reduces the likelihoods of technology adoption. The study showed there no significant influence of this variable on technology adoption in the research sites (p = 0.144), Kavre (p = 0.529) and Chitwan (p = 0.502). So the general hypothesis that distance reduces the likelihoods of technology adoption was not supported in this study.

Cost of technology (price of rice seed). It is generally hypothesized that a higher cost of the technology reduces the possibility of technology adoption. In this study, it was found the cost of seed for improved rice variety was not significant for technology adoption in the research sites ($p = 0.412$), Kavre ($p = 0.115$) and Chitwan ($p = 0.900$). So, a general hypothesis that cost of technology might limit the adoption was not supported by the finding of this study.

Economic benefits of technology. It is considered that expected benefits of technology can influence technology adoption. It is found that the perceived economic benefits were highly significant in terms of technology adoption in the research sites ($p = 0.000$), Kavre ($p = 0.002$) and Chitwan ($p = 0.028$).

The exponential of co-efficient (EoC) β was found to be 3.6. This means the odds for adopters who thought the new improved variety could enhance their livelihoods enhancement were 3.6 times the odds for those who perceived livelihoods enhancement was not important to adopt new rice varieties. At district level, the odds of adopting new technology in Kavre and Chitwan districts for those who thought the new improved variety could enhance their livelihoods enhancement were 4.7 and 3.4 times respectively the odds for those who perceived livelihoods enhancement was not important to adopt new rice varieties.

These findings showed that perceived economic benefits had more influence in Kavre than in Chitwan in terms of adoption of new rice varieties. So, the result showed that the general hypothesis that the perceived relative benefit influences on the adoption of improved rice variety and IPM was supported in this case.

Non-economic benefits of technology (straw availability). It was hypothesized that the perceived non-economic benefit also influenced technology adoption. The study found that non-economic benefit, i.e. straw availability (quality and quantity) had significant influence on the adoption of improved rice variety in the research sites ($p = 0.000$) and Kavre ($p = 0.000$) district, whereas it is not the case in Chitwan ($p = 0.238$).

In aggregate, the EoC for the β- value for straw availability was 3.099. This means that the odds of adopting IRV in those farmers who perceived that the non-economic benefits of improved rice variety were important were 3.1 times for those who did not think the economic benefits of rice varieties were important for adoption.

In Kavre, the odds of adoption of the technology, for those who perceived non-economic benefits of improved rice variety were important, were 4.47 times the odds of those who did not think other utility of rice varieties were important for adoption. The analysis showed that the farmers of Kavre considered non-economic benefits more important than the farmers of Chitwan. So, a general hypothesis that non-economic benefits influence agriculture technology was supported by the findings of the study.

Ease of use of technology. It is generally thought that ease of use of technology has positive influence on technology adoption. But, this variable was not found influential in the technology adoption process in the research sites ($p = 0.058$), Kavre ($p = 0.991$) and Chitwan ($p = 0.858$) districts.

Disembodied Technology (IPM)

Based on logistic regression analysis (Table 9, Annex 5), the following sections provide significance and level of contribution of ethnicity, age, gender, farm size, farm income, access to extension services, access to agriculture loan, market distance, seed price, relative economic benefits, other utility/benefits (human health impact) and ease of use of technologies in IPM in the research area and two districts.

Ethnicity. The general hypothesis is that ethnicity has influenced technology adoption. The multivariate regression analysis showed that the ethnicity significantly contributed to IPM technology adoption in the research sites (p = 0.008) and Kavre (p = 0.023), whereas it was not the case in Chitwan (p = 0.199). The data showed that the odds of IPM technology adoption for *Janajatis* was 0.207 times (or 80% lower) the odds of adoption for the *Brahmin* and *Chhetris*. At the district level, ethnicity was significant in Kavre district with an odds ratio of 0.023. This showed that the adoption of IPM by *Janajatis* and others very less than BCTs. So, the general hypothesis related to ethnicity was supported by the findings of the study.

Age. Age is thought to negatively affect agricultural technology adoption. The study found that age was negatively correlated with adoption but it was not found to significantly contribute to technology adoption in the research sites (p = 0.084), Kavre (p = 0.218) and Chitwan (p = 0.509). These results showed that the proposed hypothesis was not supported by the findings of the case.

Gender. It is hypothesized that gender does not influence technology adoption as technology adoption is a household-level decision. But the study found that gender was found to be highly influential determining factor in the research sites (p = 0.009), but not at district level.

The data showed that the odds of IPM adoption is 77% (EoC = 0.227) lower for males than for females, holding other explanatory variables fixed. The analysis showed that women were more progressive than men. Based on these results, the a priori hypothesis was not supported by the findings of the study.

Farm size. It is hypothesized that farm size is positively related to agricultural technology adoption. It was found in the study that the variable was not significant in the research sites (p = 0.304), Kavre (p = 918) and Chitwan (p = 0.144).

The coefficient showed a negative correlation. So, it showed the hypothesis was not supported for IPM.

Access to resources (agriculture loan). It was considered that the access to loan can influence technology adoption. The study findings showed there was no influence from loan in technology adoption in the research sites ($p = 0.574$), Kavre ($p = 0.382$) and Chitwan ($p = 0.835$).

Hence, the general hypothesis that availability of agricultural loans promotes more technology adoption was not supported by the findings of the study.

Access to resources (agriculture extension services). It is generally hypothesized that access to agriculture extension services enhances the likelihoods of technology adoption. The study showed this variable was statistically significant in the research sites ($p = 0.014$) and in Chitwan district ($p = 0.011$).

The data analysis showed the odds of adoption of IPM technology with good access to agriculture extension service was 3.7 times the odds of the adoption of those farmers without access to extension services holding other explanatory variables constant. In the case of Chitwan, the odds ratio was found to be 7.8. So, the general hypothesis in this case was supported by the findings of the study.

Cost of technology. It is generally hypothesized that higher costs of the technology reduces the possibility of technology adoption. In this study, it was found the cost of seed for IPM was not significant in the research sites ($p = 0.490$), Kavre ($p = 0.717$) and Chitwan ($p = 0.651$). So, the general hypothesis was not supported by the findings of the study.

Perceived economic benefits. Expected economic benefits of the technology are considered so that they can influence technology adoption. In this case, this variable was not found to significantly contribute to the adoption of IPM technology in the research sites (p = 0.758), Kavre (p = 0.492) and Chitwan (p = 0.899). So, the results showed that the general hypothesis of perceived economic benefits on IPM adoption was not supported by the findings of the study.

Non-economic benefits. It is hypothesized that the perceived usefulness or benefits (other than economic) of technology influences technology adoption. The study found that usefulness in terms of its likely impact on human health and environment has influenced the adoption of improved rice variety in the research sites (p = 0.000), Kavre (p = 0.0.023) and Chitwan (p = 0.005).

In aggregate, the odds ratio in adopting IPM technology for those farmers who thought IPM was important for protecting human health and environment was 8.3 times the odds of the adopting IPM technologies for the former who were not aware of the perceived usefulness of IPM technology. The EoC value for Kavre and Chitwan were 2.1 and 8.9 respectively. The analysis also revealed that farmers in Chitwan were more influenced by the consideration of other usefulness of IPM while selecting the technology. The findings showed that the hypothesis was found to be supportive in this case.

Ease of use of the technology. It is generally thought that ease of use of technology has positive influence on technology adoption. In aggregate, this variable was not found influencing IPM technology adoption in research area (p =0.065) and Kavre (p= 0.556) but the variable was found to be significant in Chitwan (p = 0.32). In Chitwan, the odds ratio of adopting the IPM technology of the farmers who felt the existing IPM technologies were easy to use was 5.2 times the odds of the adoption of IPM technologies who did not see IPM as easy technology to adopt. In aggregate the hypothesis was not supported by the findings of the study.

Major Findings

In case of embodied technology (IRV), the analysis showed that age, farm size, perceived economic benefits and non-economic benefit were found to be statistically significant in the research area. In case of relative contribution analysis, non-economic benefit was the main positively contributing factor followed by economic benefits and farm size. Among them, age is the least influential with negative relation.

Whereas for disembodied technology (IPM), the data analysis shows that ethnicity, gender, access to extension services and non-economic benefits (human health impact) were found to be statistically significant in the research area. Among them, the main determining factor was perceived contribution to human health, followed by access to extension services, gender and ethnicity. *Janajatis* were found to be less likely to be adopters and women were more progressive in agricultural technology adoption.

Formal Education, Human Capital and Technology Adoption

The third research question explored the relation between formal education and human capital formation. The research question for this was: to what extent formal education can contribute to human capital. For this, the research hypothesis is formal education positively influence on human capital theory of farmers. As formal education was not significantly contributed to disembodied technology, the analysis only considered the embodied type of technology.

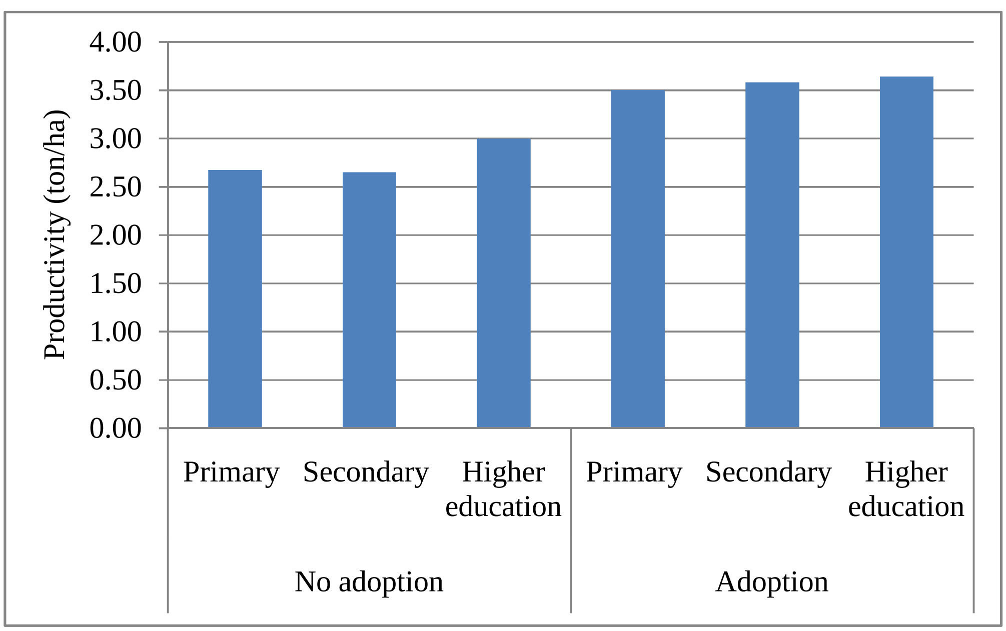
Two Effects of Formal Education on Human Capital Formation

Education, as a factor of production, presents two-fold effects on work performance. The role of formal education in creating human capital has been analysed by using two constructs of human capital i.e. 'work effect' and 'allocative effect' (Welch (1970). These constructs were considered for analysis in this study.

Work Effect. In this study, 'work effect' is related to work efficiency realized by farmers by adopting new technologies. There can be various areas of assessing the work effect but one of them is to increase in productivity of the rice after adoption of new rice. The hypothesis was that formal education can contribute to 'work effect' of farmers.

The data shows that there was a difference between the productivity of rice in IRV adopters and non-adopters. The record showed that in total the productivity of adopters was 3.55 ton/ha, whereas in case of non-adopters it was 2.67 ton / ha (national average for 2012/13 is 3.2 ton/ha). The non-parametric Mann-Whitney Test showed that there was significant [Asymp. Sig. (2-tailed) 0.000] relation between adopter and non-adopter in terms of their rice productivity.

Figure 4. Rice Productivity by IRV Adoption by Level of Education



The productivity can be influenced by other than formal education, so another analysis relating with education and productivity was also carried out. The comparative analysis of education (primary, secondary and higher) with adopter and non-adopter showed some notable differences (Figure 4).

In addition, the rice productivity of the study sites was also categorized into two groups, i.e. more than and less than based on the average rice productivity (3.4 ton/ha) in the study sites and the rice productivity was regressed with education (as explanatory variables). The simple regression showed that formal education showed significant influence ($p = 0.001$) in rice productivity. The data analysis shows that the odds of increasing productivity for one year increase in formal education is 15% ($b = 0.141$, EoC = 1.152).

All these analysis showed that a positive influence of formal education with productivity enhancement. So, the analysis showed the strong and positive work effect of education.

Allocative Effect. The ‘allocative effect’ is assessed through the marginal change in adoption rate with change in one unit of formal education. The multiple regression showed that formal education is statistically significant with embodied technology (improved rice variety) adoption ($p = 0.012$) and the marginal change in formal education would increase technology adoption by 9%.

Similarly, education categories (primary, secondary and higher) had also shown the higher ‘allocative effect’ with farmers who had higher education. The multiple regression of education categories (primary, secondary and higher) showed that odds of adopting improved rice variety by respondents with secondary and higher education are 1.8 and 5 times the odds of respondents with primary education.

Based on the analysis of contribution of formal education on human capital development (human capital theory) was positive and significant in case of embodied agricultural technology so the hypothesis that formal education contribute to adoption of embodied technology was true.

Major Findings

The data analysis showed that formal education has supported formation of human capital in the form of work effect and allocative effect as suggested human capital theory that lead to technology adoption process.

Essence of the Chapter

In case of embodied technology (IRV), the analysis showed that age, formal education, informal education (group participation), farm size, perceived economic benefits and non-economic benefit found to be statistically significant in the research area, whereas disembodied technology (IPM) was found to be influenced by non-formal education, informal education (group participation), ethnicity, gender, access to extension services and non-economic benefits (human health impact).

It was also revealed that formal education influenced more to embodied technology and non-formal education contributed significantly in adoption of disembodied technology, whereas informal education through participation in local groups influenced both type of technology. Although the contribution of formal education was not strong, it played important role in human capital development of farmers.

CHAPTER V

TECHNOLOGY ADOPTION - UTILITY AND KNOWLEDGE MATTERS

Identification of determining variables for agricultural technology adoption has become an interest for many economists, policy makers, agriculturists and extension workers. Based on the results of this study in Chapter IV, this chapter critically examines the findings in light of the state of technology adoption as outlined in the background chapter and tries to explore the meaning of the findings in agricultural technology adoption in small farming context. It discusses how education (formal and non-formal) contributes to the adoption of embodied and disembodied agricultural technologies. It also discusses how socio-economic, personal and technological attributes influence differently to the types of agriculture technologies. Finally, it discusses the nexus of formal education and human capital development for improving agricultural technology adoption process in Nepal.

Education and its Influence on Type of Technology

The findings showed that the type of education, such as formal and non-formal, influenced differently on the adoption of embodied and disembodied agricultural technologies. The following sections provide an analysis of the effects of the type of education on technology adoption.

Formal Education and Embodied Technology

The embodied technology, i.e., improved rice variety, is the agricultural technology most commonly used by farmers. This technology is easily available in the market. It can be adopted by a single household based on the perceived benefits from the technology. Farmers do not require extensive technical knowledge to use such technology, but it requires proper analysis and assessment of benefits and risks of adopting new technologies during the selection of technologies. Farmers, therefore, need analytical skills and logical thinking to assess potential benefits and risks of new technologies.

Many educationists, economists, and development planners view that formal education promotes cognitive skills and abstract reasoning ability. For example, Weir (1999) argued that formal education has both cognitive and non-cognitive effects that help to improve farmers' productivity. Others such as Nelson and Phelps (1966) show that '(formal) education enhances one's ability to receive, decode, and understand information' and also 'educated people make good innovators, so that education speeds up the process of technological diffusion' (p.70). Hence, farmers with higher formal education are more likely to possess higher analytic capability to assess the potential benefits and risks while taking decision of selecting technologies. So, formal education helps to take more informed decisions in a specific context in order to adopt embodied agricultural technology.

The finding of this study was consistent with the findings of other similar studies. For example, Ghimire et al. (2015) carried out a study in Nepal (including Chitwan and Kavre) and the study found that education played a positive and significant role in adoption of new rice varieties. Lin (1991) also found that formal education had a positive effect on the probability of adoption of hybrid rice (embodied technology) by Chinese farmers. Similarly, Khanal and Gillespie (2013), a study on the adoption of profitability of advanced breeding technologies in the US dairy farms, found that more educated operators have longer planning horizons and the operators are more likely to adopt advanced breeding technologies.

The study also showed that secondary education had significant positive impact on technology adoption compared to primary education. This higher rate of technology adoption by farmers with secondary education was mainly due to that the longer opportunities of having additional knowledge and skills through formal education that helps to assess the potential benefits and risk of new technologies.

The existing agriculture extension strategy in Nepal has not captured the potential role of farmers' formal education in the adoption process of agricultural technologies. Generally in Nepal, it is believed that educated persons do not run farms. It also considered that formal education is not so useful for farming. In the past, agriculture was predominantly subsistence-oriented. However, the traditional farming systems are being transformed into more commercialized form, which requires a lot of knowledge to manage risks and explore opportunities on the part of farmers. These requirements for enhanced knowledge have yet to be integrated in policy frameworks, including in the current extension strategy.

Non-formal Education and Disembodied Technology

The finding showed that disembodied technology, i.e., IPM, is significantly influenced by non-formal education. Disembodied agricultural technology mostly appears in a package of field-based technical knowledge that can be shared by many farmers at the same time. IPM is a consciously organized practical pest management package for farmers. IPM field demonstrations are organized under IPM programmes for about three months, where farmers get knowledge and skills through an interactive learning process. In this process, IPM experts and farmers interact directly by taking some specific farming challenges and solve problems through learning-by-doing method. Mostly, adult farmers participate in IPM; so, appropriate pedagogic processes relevant to adult learning are also followed. In addition, IPM experts also adapt the contents as the farmers' learning advances and ensure the process is 'learner-centred' and useful.

In order to promote this type of technology, an education system that can allow for consciously organization of curriculum to serve the particular interest and learning needs of farmers. Non-formal education is proven to be effective for critical pedagogy and innovative approaches (Delors, 1996). In addition, non-formal education also encourages self-directed learning, critical reflection, experiential learning, and learning to learn, and these are unique and exclusive for adult learning processes (Brookfield, 1986).

The review of epistemic and pedagogic processes of education types shows that non-formal education is most appropriate to provide the above-mentioned requirements for adoption of disembodied technologies. Non-formal education most often transmits specific knowledge needed to solve a particular problem. It is always consciously organized based on the needs of the client and is flexible in its structure and method to achieve clearly-defined objectives. Hence, non-formal education can support the adoption of disembodied technology better.

The existing extension strategy has neither captured the essence of the non-formal education learning purpose nor has it clearly mentioned the diversity of the teaching-learning process that is needed for different types of agricultural technology. This is mainly due to weak understanding of the basic principles of the teaching-learning process based on the agricultural technology and the context of farmers.

Informal Education and Technology Adoption

The role of informal education through participation of local groups was statistically significant for both types of technologies. Informal education is considered as a part of learning for generations in agriculture. It is assumed that farmers get reliable information from oral transmission and site observation, which shape the attitude and behavioral change of the farmers towards technology adoption for both embodied and disembodied technologies. In the rapidly changing socio-economic and political contexts, the need for informal education through participation of local groups of farmers is considered instrumental for technology adoption. Evidence shows that informal education has comparative strength against other types of education. Informal education through participation in group is mainly based on the learning from exposure to one's environment and day-to-day experience from group members.

In most of the smallholding farming communities in Nepal, farmers also acquire knowledge and learn new technologies from other trained and experienced farmers of their groups. This kind of informal learning and diffusion usually occurs during group meetings and informal conversations in teashops. It can also be called as private oral transmission. For example, some farmers test new seeds in their field and, based on his or her experience, other farmers take decision of adopting or not adopting the technology. In the same way, farmers share the benefits of IPM and its likely impact on human health and environment with their peers in the groups they are involved with. So, informal education through participation in local groups is likely to play an important role in technology adoption. This kind of diffusion happens spontaneously, but the effectiveness of the use of knowledge depends on kind of technology and level of understanding and interest of the farmer. Although knowledge transmission through informal methods while participating in a group may not always be up-to-date and accurate, they are most of the time considered trustworthy by farmers.

These findings are in line with the earlier studies carried out by other researchers. For example, Foster and Rosenzweig (1995) found that the group members' experience was influential in technology adoption in India. Similarly, Kormawaet al. (2004) found that group learning is important, especially where formal methods are inefficient. They explored the role of group members through farmer-to-farmer extension method in knowledge transfer and dissemination of an improved cowpea seed variety in Nigeria, and they found that the extension method was effective in transferring the improved cowpea variety among farmers.

Informal education through group learning has not been a strong part of the extension strategy for technology adoption so far. The value and relevancy of the group learning process in agriculture development programme has not been considered as an important component for technology promotion in Nepal. The main reason for inadequate integration of role of local groups in the existing extension is mainly the weak understanding of the role of informal education in the technology adoption decision-making process.

Personal, Socio-economic, Technological and Enabling Environment Factors

Various independent variables such as personal attributes, socio-economic characteristics, technological attributes, and enabling environment were found influential in technology adoption. The following sections provide some discussions based on the findings presented in Chapter IV.

Ethnicity

The analysis showed that ethnicity was influential to IPM practices, whereas it was not influential in the case of adoption of improved rice variety. In this study, the ethnicity had three groups, i.e., i) *Brahmin*, *Chhetri,* and *Thakuri* (BCT); ii) *Janajatis* (hill ethnic group: *Gurung, Magar, Tamnag, Newar,* and *Rai,* and *Terai-Madhesh* ethnic group: *Tharu* and *Darai*); and iii) *Dalit* and others. The composition of BCT, hill ethnic communities, *Terai-Madhesh* ethnic communities and *Dalit* were 73%, 13%, 12%, and 1% respectively. Analysis of these groups showed that BCTs were the most receptive in new technology adoption. The main reasons for these varied effects of ethnicity on technology adoption can be attributed to the specific social and ethnic attributes of these groups and access to information.

In the case of embodied technology, the main reason for weak influence of ethnicity is attributed to the proprietary nature of technology. Embodied technologies are generally managed (production and distribution) by traders and private companies in more structured ways. Buying and using improved rice varieties is mainly based on personal interest and perceived benefits by individuals. Thus, the ethnic attributes have little role to play in adoption process of embodied technology.

This variable was however significant in disembodied technologies. IPM is a knowledge-intensive technology and the technology requires a group approach to manage. *Janajatis* have their own attitudinal and knowledge stratification, and knowledge systems with their stronger traditional bonds. These social characteristics determine to form attitudes towards new technologies jointly. This might however take a long time to have positive attitudes on new technologies. Adoption of IPM technologies needs a group approach and most the *Janajatis* have strong communal bonds. Hence, adopting IPM in case of *Janajatis* may take a longer time compared to BCTs. This could be attributed to the low adoption of the technology by *Janajatis*. On the other hand, *Brahmin, Chhetri* and *Thakuri* (BCT) are considered to have more access to resources and have proactive attitudes and behavior, which might be the reason for being innovative and early adopters compared to *Janajatis*. For example, in this study, about 60% of the farmers from the BCT group had access to agriculture extension services, whereas only about 44% from *Janajati* and other groups had to extension services.

A brief analysis was carried out to explore disaggregated relationship among and within ethnicity. In the case of the IRV, the percentage analysis showed that out of total BCT respondents, about 80% (315 out of 400 BCT respondents) of the farmers had adopted the new technology. Within ethnicity, about 65% of the hill ethnic groups (*Magar, Gurung, Tamang, Newar,* and *Rai*) had adopted technologies whereas the adoption rate among the *Terai-Madhesh* ethnic group (Tharu and Darai) was about 78%. This analysis indicates the rate of technology adoption with ethnic groups in *Terai-Madhesh* was higher compared to ethnic groups in the hills. This can be attributed to the greater exposure of *Terai-Madhesh* ethnic groups to market and agriculture knowledge systems.

In the case of IPM, about 56% of BCT adopted the technologies. The adoption rate of IPM compared to IRV is less among the ethnic group. It could be due to the fact that BCT group is more focused on profit making objective, which can be achieved through improved rice varieties. The percentage analysis showed that only about 25% of hill ethnic groups adopted the technologies whereas about 43% of the *Terai-Madhesh* ethnic group adopted the technology. In this case as well, the ethnic groups in Terai were found to be more receptive to agriculture technology adoption.

Overall, the analysis showed that BCTs had higher adoption rate in both technologies and within the ethnic groups, the *Terai-Madhesh* ethnic groups more responsive to adopt the technologies compared to hill ethnic groups. The main difference between BCT, *janajati* and *Dalit* could be attributed to the less access of information and inadequate awareness to the *Dalit* and *janajati* communities compared with BCT. This could also be related to the social structure and access to resource that Nepal has practiced for long. According to Bennett (2006), caste and ethnic identify also influence poverty and vulnerability outcomes, so they may have less access to productive information and resources.

According to Floyd et al. (2003), a study carried out to map adoption of 15 agricultural technologies in crop, horticulture, livestock and forestry production in western hills of Nepal, ethnic communities (such as Gurung and Magar) have less awareness on innovative agricultural technologies than the Brahmin/Chhetri group. They also found that *Dalits* (occupational caste) were less likely to adopt technology as they are traditionally less dependent on agricultural production for their livelihood. Neupane et. al (2002) carried out study on technology adoption related to agroforestry (a disembodied technology) in Dhading districts and found that the technology adoption rate was higher in the case of *Brahmin* and *Chhetris* groups compared to ethnic communities such as *Gurung* and *Magar*.

Similarly, Harris (2011) carried out a study on IPM adoption in Nepal and found that compared to the *Janajati*, *Brahmin*, *Chhetri* and '*Dalits*'. The study found that farmers from lower castes adopted fewer IPM practices. The *Dalits* were using only one IPM technologies whereas other ethnic communities adopted more than 3 IPM technologies at the same period of intervention time. The study also revealed that the ethnic communities in *Terai-Madhesh* had higher adoption rate than ethnic groups in hills.

In general, ethnicity and its possible roles in technology adoption have not been taken into account in the agriculture extension system. In addition, there has not been adequate research on the extent of ethnicity as a factor in technology adoption. Hence, these independent variables have remained mostly out of agricultural policy framework.

Age

Age had negative influence on technology adoption in this study. The effect of age is statistically significant in the case of improved rice variety (embodied technology). It is because older people are more skeptical of new technologies as compared to the youth. It is also difficult for old farmers to learn how to use technology effectively. Besides, they are not willing to take risks, whereas young farmers are more risk-taking and want to invest for longer term.

The findings of this study are similar to those of other studies. For example, Green and Ngongola (1993), in their study on adoption of fertilizer in Malawi, found that age had negative relationship to adoption. Similarly, Khanal and Gillespie (2013) found that younger operators having longer planning horizons were more likely to adopt advanced breeding technologies in the USA.

The study showed that the youth were more willing to adopt agricultural technology than older people. But, on the other hand, they are migrating from their villages in search of job. So, retaining the youth in agricultural profession has become an important challenge. The existing agricultural policy framework has as one of its objectives to attract the youth towards agriculture, but the operational strategies have not been effective in retaining the youth in the sector.

Gender

The study showed the influential role of gender in IPM, whereas it was not significant in the case of IRV. It is generally assumed that women are more constrained to access productive resources such as land, credit and information, which may limit their adoption of new technology. But, this study showed that women were more progressive than men, especially in disembodied technology adoption. One of the reasons was the prolonged absence of men in farming and women had the additional task of managing their farms as well. In Kavre, for example, about 42% of young men (16 -45 years) have migrated for jobs and, in turn, send remittances, which helps women to become forward-looking in adopting new technologies in agriculture (Gartaulaet al., 2010; Tamang et al., 2014).

In addition, the government has adopted the strategy of promoting female participation in agricultural programmes such as IPM. Ministry of Agricultural Development emphasizes formation of women groups for promotion of agriculture technologies (MoAD, 2014a), and the programmes have tried to include women in their activities as much as possible. Hence, women are more likely to get additional opportunities to be involved in disembodied type of technology promotion.

These findings are in line with the findings of other similar studies. Gartaula et al. (2010) found that women had to broaden and deepen their involvement in agricultural work for household survival and become more technology-friendly due to massive out-migration of men for employment. Doss (2001) and Ogato et al. (2009) also found the role of women in crop management, technology adoption and group management better compared to men.

This finding has important policy implications, both for agriculture extension and for agriculture programme management. Generally, it is assumed that women are less progressive in adopting technology as they have less access to and control over resources. But, based on the findings of the study, women can adopt technology better if they get such opportunities.

Farm Size

The study showed mixed influence of farm size on technology adoption. Farm size was positive and statistically significant for IRV adoption, whereas it was not statistically significant for IPM. In the case of IRV, the main reason can be attributed to the scalability of technology. Scalability in technology adoption can be promoted when the technology is easily available and easy to use by farmers, incremental cost of integration in the existing farming systems is small, and it does not require much technical knowledge but can still fetch benefits.

IRV, an embodied technology, is easily available in the market, the incremental cost of adopting new technology is low, and no intensive knowledge is required to cultivate new varieties and it can also have economic benefits as the scale goes up. Due to this relatively simple nature of technology and possibility of easy integration in the existing farming systems, IRV has greater scope of scalability in a large area.

This finding is consistent with the findings of other studies. Ghimire et al. (2015) carried out a study in Nepal and found that land size of farmers played a positive and significant role in adoption of new rice varieties. A study carried out by Keelan et al. (2009), Thorne, Flanagan, Newman and Mullins (2009) show that the farm size is one of the major factors that influences the decision of Irish farmers to adopt genetically modified (GM) technology (embodied technology).

Conversely, in the case of IPM, farm size was not influential, but it showed a negative relation to technology adoption. The main reason for this was the scale-sensitive nature of disembodied technology. IPM is a knowledge-intensive technology which requires technical competency and need group approach to ensure IPM performance.

In addition, farmers' field schools have their own cost and are often expensive if farmers have to pay the cost incurred. The actual cost invested per farmer in IPM programme was not available in Nepal, but a study carried out in Bangladesh shows the cost of IPM is about US$30-50 per farmer to manage a farmers' field school per season (Ricker-Gilbert et al., 2008), and this is considered expensive in the Nepali context. These were the reasons for negative relation of land size to technology adoption.

The finding of this study is consistent with those of other studies. For instance, Ridgley and Brush (1992), Waller et al. (1998) and Samiee et al. (2009) reach the conclusion that farm size does not influence the IPM adoption process positively as managing IPM at larger scale is a costly and time-consuming process.

Existing technology development and extension mechanisms in Nepal have not integrated this aspect in technology adoption. Farm size in technology adoption could be an important learning for the agriculture planning process.

On-farm Income

Literature shows that on-farm income, generally, has a positive impact on technology adoption. This is because on-farm income acts as an important resource for overcoming credit constraints faced by rural households. But, in this study, on-farm income was not statistically significant because of the labour- and knowledge-intensive nature of IPM and low incremental cost of IRV when integrating technology into the existing farming systems.

In the case of IRV, the incremental cost of improved seed in the farming system is not considerably high as the cost of improved seed is minimum compared to those of other inputs such as chemical fertilizer and pesticides. If farmers are aware of the benefits of IRV, even farmers with low on-farm income can buy technology easily. In the case of IPM, the technology is knowledge and labour-intensive; so, farmers may want to use their financial resources for other less labour-intensive farming activities and limit their involvement in such practices. This could be a reason why on-farm income was not significant.

Media Contribution

The role of media was not statistically significant with both types of technology. The main reason is the weak content relevancy and low frequency of the information on appropriate technology provided to farmers through media, i.e., radio, television, and newspapers. An agricultural information service needs to be quick, contextual, understandable, and timely, which can then provide better services to farmers who are mostly illiterate or barely literate. In Nepal, the government has initiated radio and television programmes, but they were not so influential as most of the radio programmes were weak in providing practical content in a language understood by the farmers on regular basis. In addition, most of the smallholding farmers do not understand technical language spoken by media presenters.

A study carried out by Nwankwo and Orji (2013) supported this finding. The study shows that messages shared through media are not easy to understand and so did not affect the agricultural technology adoption process. With the increasing role of media through appropriate use of information, communication and technology (ICT) for technology adoption, the role of media is important and the possible benefits of ICT are yet to be integrated in the Nepali context.

Access to Agricultural Loans

There is a general hypothesis that credit is important for technology innovation. Hoff, Braverman and Stiglitz (1993) argue that weak access to credit can negatively affect the adoption behaviour. This study, however, shows that access to agricultural loans from banks was not an influencing factor in the agricultural technology adoption. As farmers have easy access to informal loans from local groups, they prefer to take loan from local savings and credit groups instead of following the existing bureaucratic processes of getting loans from commercial banks.

In Nepal, there has been a rapid expansion of community-based savings and credit programmes, which have helped to enhance access of loan to farmers. Gingrich (2004) shows that savings and credit groups provide a variety of microfinance services to households in Nepal. Besides, people receive a lot of remittances from foreign employment (Tamang et al., 2014) and this has also helped to get easy access to agricultural financing, whereas in the case of accessing institutional loans, farmers need to provide collateral, pay a fee for loan processing, and visit those financial institutions for at least a couple of times for loan processing until the loan is sanctioned. Due to these bureaucratic hurdles, institutional loans are least preferred source of financing by farmers. So, it has less influence on the technology adoption process.

This analysis showed that small farmers can have easy access to agricultural loans from local savings and credit groups, but they have to pay higher interest rate compared to institutional loans. The government has recently initiated the process to provide loans to farmers at a low interest rate. This is an appropriate step in favour of farmers, but the process for getting loan needs to be more farmer-friendly.

Access to Resources: Market Distance and Extension Services

The market is an important source of knowledge for new technologies. Proper access to the market is, therefore, important for technology adoption. In general, long distance to the market inhibits access to knowledge and technology. It is assumed that long distance affects technology adoption negatively. In the case of improved rice variety, distance to the market centre did not have any influence on technology adoption. In the studied sites, all the VDCs and municipalities were within 15 km from the district headquarters or knowledge centre, and the villages had good access to road and telephone communications. This is the main reason for distance to market not having an influence on the adoption process in this study.

For IPM, access to extension services is vital to get latest information on IPM. The study showed that this variable was statistically significant for IPM. IPM is a knowledge-intensive technology which requires a lot of technical support from experts at least for one cropping season. In this case, farmers need adequate technical skills and competency to practice IPM, which they are expected to get from IPM extension workers on a regular basis. For example, when farmers know about the types of pest, types of IPM options and have some understanding of technical concepts such as economic threshold, they can use appropriate type of pest control measures. So, until and unless farmers have good access to extension services and develop confidence in the use of techniques, they do not adopt IPM technology. This shows that access to extension services was influential in adopting knowledge-based technology.

The findings of this study were similar to the research carried out by Elsey and Srikichoti (2002) for durian cultivation in Thailand. They indicated that when IPM knowledge was transferred by agriculture extension workers to farmers, the farmers developed their confidence to use IPM technologies. The extension workers also helped to establish collaborative partnerships and promoted learning as an effective means of managing change in complex environments.

The analysis showed that an appropriate knowledge base, i.e., regular support from extension workers, is important for adoption of IPM. So, adequate access to knowledge in the case of disembodied technologies is important for effective adoption.

Cost of Technology

The cost of modern agricultural production technologies was not statistically significant to both technologies. This means that if an agricultural technology is relatively expensive to farmers, then there is low probability of their adopting it.

In the case of rice, the improved seed usually costs about NRs 60-80 per kilogram. The incremental cost of total production system is nominal as the major cost of rice cultivation is related to fertilizer, field preparation and human labour. According to Foster and Rosenzweig (2010), a key determinant of adoption of a new technology is the net gain to farmers, inclusive of all costs of using the new technology. In this case, the incremental cost of new technology is less; so, the variable was not influential for new technology adoption. In the case of IPM, technology itself is not expensive for farmers as the IPM initiative was supported by a government programme. Farmers invested their time and developed technical competency. So, they regarded that cost was not a big deal compared to the total cost of production of their crops. This was the main reason the cost of technology was not an important factor for technology adoption in the study area.

The analysis shows that the cost of the technology is not related to the technology adoption process as long as it ensures benefits at the end. It is, however, important to know the threshold level of incremental cost of new technologies against the total production cost.

Perceived Economic Benefits of Technology

Perceived benefits of technology adoption is one of the important factors for technology adoption. The results of this study showed that the perceived economic benefits, especially its contribution to economic returns to farmers, were significantly influential in IRV, whereas this was not the case in IPM.

Rice is the main source of livelihood and income for most of the farmers. In addition, it is the main staple food for about two-thirds of Nepal's population. So, farmers expect to use improved rice varieties that provide economic benefits to support their livelihoods needs. Hence, perceived economic benefit of new technology is a highly influential factor for IRV adoption. This finding is consistent with the findings of a study carried out in Nepal by Ghimire et al. (2015). The study found that relative benefits played a positive and significant role in adoption of new rice varieties. Similarly, another study carried out in Kashmir, India, on improved rice varieties by Waniet al.(2013) also showed that adoption of new varieties of improved rice were dependent on the perceived economic benefits of new technology. But, in the case of IPM in this study, the motivation for adopting technology was related to producing healthy food. So, economic benefit was not influential to IPM.

A strong economic rationale for adoption of new technology can, therefore, be found in the case of embodied technology, whereas for disembodied technology, direct economic benefit was not the main factor for technology adoption. Existing agriculture policies, including agriculture extension strategy, have taken into account economic rationality in choosing technologies, but other important aspects such as market and technical efficiency are not considered in agriculture programmes. Thus, farmers are not able to get good economic returns as expected from new technologies. The findings can provide a basis to select appropriate technologies based on economic rationality.

Non-economic Benefits

It was found that these non-economic variables (rice straw and human health) significantly contributed to adoption of both types of technology. Bliss and Stern (1982) note that markets are imperfect and institutions for agriculture development do not function as expected in most of the developing countries; so, farmers have to face a lot of stochastic production risks. The situations also prevail in the study area and this may be the reason why only economic rationality cannot determine the technology adoption in small farming context. This study also indicates that smallholding farmers were interested to maximize the utility of new technology by adjusting both economic and non-economic variables instead of depending only on economic profit. This study showed that farmers had a trade-off between economic profit and non-economic benefits.

In the case of IRV, availability of rice straw was found to be highly influential for technology adoption. Nepali farming systems are mostly integrated with crop, livestock, and forest. Livestock provides nutrition, income, and farm manure for a family. In order to keep livestock, they need rice straw; so, availability of good quality and quantity of straw is important for smallholding farmers. According to Basnet (2008), rice straw meets about 32-37% of total digestible nutrients required for livestock in Nepal. In this case, this is the main reason for non-economic factors having significant influence as the determinants of technology adoption. This finding is consistent with the findings of Joshi and Bauer (2006). The study carried out in western Nepal shows that availability of rice straw is one the determining factors of adoption of new rice varieties.

The findings of this study were also corroborated by studies carried out outside Nepal. Adesina and Baidu-Forson (1995), for example, use farmers' rationality concept in the technology adoption process. They found in Burkino Faso that farmers' subjective perception, especially non-economic and non-agronomic technological output, equally influences the adoption process. They found that adoption of sorghum varieties was mainly based on the applicability to grinding of the varieties than on the increased output.

The non-economic benefits were found to be highly influential on IPM adoption. More than 90% of the farmers in this study mentioned that they knew the negative impact of chemical pesticides on human health, as well as on the environment. In the last two decades or so, farmers have become aware of the negative impact and economic costs of pesticides. According to Atreya (2007), farmers are aware of the negative impact of pesticides in Nepal. He also found that households bore an annual health cost of NPR 287 ($4) as a result of pesticide exposure. So, non-economic benefits were considered as one of the key influencing factors for IPM adoption.

This analysis of both economic and non-economic rationales shows that farmers were interested to keep both types of benefit while selecting technology. So, farmers' consideration of non-economic benefits from a new technology was central to devising the technology adoption strategy.

Ease of Use of Technology

The study found that there was no influence of 'ease of use' on technology adoption. Various technology adoption models such as the theory of planned behavior, technology acceptance model (TAM) and unified theory of acceptance and use of technology (UTAUT) consider ease of use of technology as important constructs for adopting technology. But, this study showed different results. The main reason, in the case of improved rice, is related to long experience of farmers in carrying out similar kind of farming activities. The study showed that the average experience of farmers in rice cultivation was about 20 years; so, adopting improved rice varieties was not totally new for them.

Similarly, in the case of IPM, farmers used to receive technical skills through farmers' field schools and they also got continuous support from extension workers. So, they did not consider this variable as a critical factor for technology adoption. It indicates that 'ease of use' for these technologies was not an important determining factor for technology adoption.

Although this variable was not found significant in this study, ease of use could be an important factor when farmers need to adopt more sophisticated agricultural technologies independently. So, further exploration of the ease of use variable might be needed to develop a good technology adoption process.

The study also found that there is also a possibility of grouping the type of variables according to their contribution to technology adoption. It is observed that variables which are related to 'individual attributes' (i.e., personal nature) have contributed more to embodied technologies as the technology has also some adoption-related attributes such as having proprietary nature, easy to adopt by an individual (without a group) and mostly managed by private entities which can be facilitated by an individual interest. Similarly, other variables are more associated to 'collective or groups' attributes. They include gender, ethnicity, access to resources, and these are found to be influencing factors for disembodied technologies which is more influenced by social or group approach. The details of their relations are explained in Chapter VI.

Technology Adoption by Ecological Zones

The study found some variations according to the ecological zones, i.e., in Chitwan (Terai) and Kavre (hill) districts, while analysing the technology adoption process (Annex 4). In the case of embodied technology, ethnicity and gender were found more influential in Chitwan than in Kavre. For ethnicity, the main reason could be related to higher formal education and more enthusiastic attitude of BCTs to new technologies. In the case of gender, women in Chitwan were more exposed to the market and knowledge as compared to women in Kavre. Age did not matter in Chitwan, but increasing age of farmers had negative and significant influence in Kavre. The main reason for this was the high level of market exposure and timely access to information on technology in Chitwan compared to Kavre.

In the case of formal education, it had no influence on adoption of improved rice varieties in Kavre, whereas in Chitwan, the influence was statistically significant. The relation was attributed to the exposure of more commercialized agricultural production systems in Chitwan, which required more allocative ability that can be acquired from formal education. In case of Kavre, the farming systems were still subsistence-oriented; so, they continued to practice their traditional knowledge rather than using the cognitive ability derived from formal education.

Farm size was statistically significant with technology adoption in Chitwan, whereas this was not the case in Kavre. Farm size was slightly smaller in Chitwan, but good fertility and topography of farm land provided more opportunities for scaling up technology compared to Kavre district. Similarly, it was also shown that non-economic benefits (straw availability) had a significant role in technology adoption in Kavre, but not in Chitwan. The main reason for this was that, farming systems were found to be more integrated with livestock in Kavre, whereas agriculture in Chitwan was more specialized. Livestock in Chitwan was mainly based on concentrated feed rather than use of rice straw. So, rice farmers in Chitwan did not care much about the availability of straw from new rice varieties.

In the case of disembodied technology or IPM, influencing factors, i.e., ethnicity, informal education and access to extension, were important for technology adoption. In the case of ethnicity, in Kavre, BCTs were found more progressive in technology adoption, which was related to the enthusiastic nature of BCTs towards new technologies and opportunities. Likewise, informal education through participation in local groups was more influential in Chitwan than in Kavre. The main reason was that farmers were more exposed to many savings and credit and agricultural groups in Chitwan as compared to Kavre. Regarding access to extension, farmers in Chitwan were found to be more positively influenced because of easy transportation facility to market centres and DADO in Chitwan as compared to Kavre where commuting to those knowledge centres was a challenge.

In general, there were some differences related to agriculture systems in these two ecological zones, which showed varied influence on technology adoption. They were accessibility to knowledge centres, exposure to market opportunities, quality of farm land, gender empowerment, and level of integration of farming systems. These factors facilitate or hinder the perception and attitude of farmers towards new technologies and consequently determine technology adoption.

The existing agriculture policy framework does not consider such ecological variations explicitly while designing policies and extension programmes because of the policy formulation process. The policy formulation process is still dominated by the top-down approach and strategies are developed for the whole country without considering regional or ecological differences, socio-economic status of farmers, and the nature of the farming system being adopted by the farmers.

Role of Formal Education in Human Capital Development

This study focused on the possible contribution of formal education and human capital development that lead to technology adoption. As discussed in Chapters III and IV, two constructs of human capital, ‘work effect’ and ‘allocative effect', were selected to assess the contribution of formal education to human capital formation.

The study showed that formal education contributed positively to the two constructs of human capital development, i.e., work effect (agricultural productivity enhancement) and allocative effect (adoption of technology), in the case of embodied agricultural technology. This contribution was statistically significant.

The main reasons for improving the work effect and allocative effect are: formal education helps farmers to make better use of information; assists them to find better solutions from available options; improves their ability to evaluate potential risks and analyse costs and benefits between promising and unpromising innovations. These processes also help to change the attitude and behaviour of farmers and finally facilitate them to develop their reasoning ability so that they can improve the work effect and allocative ability of farmers.

The important role of education to human capital and improvement of agricultural productivity has been widely recognized in the economic literature following the seminal contributions of Schultz (1961), Becker (1964) and Welch (1970). The result of this study is in agreement with Gallacher (1999) where he used the work effect (productivity enhancement) and allocative ability (adaptation of agriculture input or new technology adoption) concepts in Brazilian agriculture. The study concludes that formal education significantly contributes to human capital development.

One of the main objectives of agriculture extension and education is to enhance human capital formation by improving technical and management skills of farmers and extension workers. However, this aspect has not been well recognized and integrated in the existing agriculture extension and education systems.

In addition, agriculture systems are shifting towards commercial farming. In this context, farmers need to know adopt and manage new technologies effectively. This requires them to increase their personal ability to take appropriate decisions on time related to technology adoption. In order to increase personal ability, formal education is highly desirable, so that human capital can be enhanced. This further necessitates improvement in formal education systems so that human capital of farmers can be enhanced to capture the opportunities and minimize the risks related to embodied agriculture technologies. But, the existing education systems in Nepal are largely uncritical and unreflective in improving the performance of the student. In fact, formal education system in Nepal has focused less on how to improve the ability of the student in order to increase their 'work effect' and 'allocative effect' when they run agricultural farms.

A brief literature review revealed that there were several lapses on the curricula and teaching practices in Nepali education systems. Mishra (2007) argues that 'the most significant and long-term problem that plagues teaching and learning is the pervading climate of uncritical and unreflective 'intellectual' work' (p. 289). Similarly, Parajuli (2015) argues that there are some fundamental lapses in the design of schooling system. One such lapse is the cultural gap – the mismatch between the schooling and its content and process on the one hand and the context of the local area and the people whom the schooling is supposed to support to develop on the other. He further argues that schooling has been detaching a large number of youths from their traditional livelihood which is most commonly related with farming and related jobs. That is why large areas of agricultural land have remained fallow in many parts in Nepal.

In addition, in most of the schools, teachers are not well trained. Most of the schools are facing problems like inadequate infrastructure (buildings), laboratory, playground; and teaching learning material (Standing, 2011). In addition, language barrier (Koirala, 2010), availability of textbooks on time and large numbers of student per teacher are some other common challenges for students in remote area (Gautam, 2008). Due to all these challenges, the learning outcome in the form of increasing knowledge, skills and ability to adopt new technologies are weak in Nepal.

The main drivers of agriculture development have also changed with globalization and liberalization processes. Due to this, there is a paradigm shift in demand and employment pattern of agricultural students in agriculture and allied sectors. In order to address this mismatch of demand and supply, continual updating of curricula is imperative (Paudel, Gill, & Rajotte, 2013) for agriculture education. Sadly, academic curricula in agriculture in Nepal which were developed often several decades ago still largely remain the same (Paudel, 2013). These could be some reasons why formal education has not been able to enhance human capital of students as expected. This is an important area of discussion how the curricula and class room practices affect agriculture technology adoption process, and this was not possible to explore in detail due to limited scope of the study, so further study in this area would be required.

Studies in other developing countries also showed similar results. A study carried out by Westbrook, Durrani, Brown, Orr, Pryor, Boddy and Salvi (2013) revealed that existing education systems was not adequately supporting the learning outcome of the students and they stressed on understanding which/what pedagogic practices, in which contexts and under what conditions are generally followed while teaching at schools.

Despite these challenges, this study demonstrated a positive but not very strong relation of formal education in enhancing human capital and improving agriculture technology adoption process in the research area. The analysis also showed that there is a possibility of having considerable contribution of formal education in agriculture technology adoption process if improvement in formal education systems can made.

An Assessment of Theoretical Link and Explanation to the Adoption Process

The utility maximization theory along with the planned behavior and the human capital theory provided a basis for development of conceptual framework for this study. The utility maximization theory is about how farmers prefer to manage their resources in order to get maximum utility under uncertainty and risk. As mentioned by Moschini and Hennessy (2001), agriculture sector has various uncertainties such as production, price, technology, and policy uncertainties, and farmers, therefore, prefer to maximize utility from new technologies (Batz, Peters, & Janssen, 1999). Nepali agriculture has also witnessed similar situations of uncertainty and risks.

In this study, it was revealed that farmers had prioritized perceived benefits – both economic and non-economic benefits from new technologies as one of the most important factors for taking decisions on agriculture technology adoption. It is also noticed that the utility maximization is also influenced by people's preference, values and assumptions (Fishburn, 1969) and these attributes are determined by farmers behavior (behavioral theory) and the level of knowledge (human capital). Hence, behavior theory and human capital theory are key to assess the utility and to shape farmers' technology adoption process.

As mentioned above, Ajzen's (1991) theory of planned behavior has three conceptually independent antecedents leading to behavioral intention, attitude toward the behavior, perceived behavioral control and subjective norms. According to this theory, attitude is an individual's positive or negative feelings (evaluative affect) about performing the target behavior (Fishbein & Ajzen, 1975, p. 216); subjective norm is 'the person's perception that most people who are important to him think he should or should not perform the behavior in question' (Fishbein & Ajzen, 1975, p. 302); and perceived control behavior is 'the perceived ease or difficulty of performing the behavior' (Ajzen, 1991, p. 188).

In this study, it was found that farmers reviewed and evaluated an overall performance (considering evaluative affect) of the technologies based on their personal attributes (age, education, gender, ethnicity), socio-economic status (farm size), enabling environment (access to resources), and perceived benefits (economic and non-economic benefits) from new technologies.

The study showed strong relation in the case of subjective norms. The study revealed that farmers get suggestions and input from their peers and develop their confidence before adopting the technologies. In this case, informal education (through group participation) and non-formal education provided this opportunity. For perceived control behavior, the study did not show significant relation to technology adoption but a positive relation was found in the case of IPM. The weak relation could be attributed to the many years of farmers' experience of cultivating rice. Considering the wide range of agricultural technologies and changing context of agriculture toward commercial farming, farmers may need to deal with some complex technologies, such as drip irrigation, so this variable might still play an influencing role for technology adoption. Hence, in general, these theories constructs were found to be significantly contributing to developing their positive attitudes toward technologies and subsequently adopting the technologies.

In the case of human capital theory, it is generally understood that education can play an important role to increase human capital that lead to technology adoption (Huffman, 2001). The study has also showed positive relation of formal education on two major construct of human capital (i.e., work effect and allocative effect) as suggested by Welch (1970) in the case of embodied technologies. In addition, informal education and non-formal education also have positive influence in adoption of disembodied technologies.

In summary, the theories i.e. utility maximization, the theory of planned behavior and human capital theory used in this study have helped to understand relations of influencing variables for both embodied and disembodied agricultural technologies in small farming context in Nepal. So, it is important to use these theories to prepare a theoretical framework of agriculture technology adoption in small farming context in Nepal.

Essence of the Chapter

This chapter discussed the major reasons of influence by different variables on technology adoption and drew some meaning of these relations. While an analysis of the variables indicates some underlying patterns of influence on overall technology adoption, the primary finding is that perceived utility (economic and non-economic benefits) and education matter and they together significantly influence the agricultural technology adoption processes.

The findings showed that the type of education and other variables have varied levels of influence according to the type of agricultural technology. The role of formal education, non-formal education, gender, farm size, age, ethnicity, access to resources, and economic benefits had varied level of influence of different nature according to the type of technology. For example, both formal and non-formal education have specific ways of sharing and transmitting knowledge, and they are, therefore, sensitive according to the type of agricultural technology. Formal education helps to promote the cognitive skills and the abstract reasoning ability of farmers, which intrinsically helps to adopt embodied technologies, whereas non-formal education follows a more dialectic way of knowledge-sharing process and imparts practical skills to farmers, which are inherently better suited to adopt disembodied technologies. These relations have not been well studied in the existing agricultural technology adoption literature and these are essentially new findings for further analysis and synthesis.

The study also showed some variations in influence of variables according to districts. The districts represented two major agro-ecological zones and had some basic differences in climatic and non-climatic variables. The study identified that these districts had differences, especially in availability of knowledge on new technology, exposure to market opportunities, farmland quality, gender empowerment, and level of integration of farming system. These could be the reasons for differentiated influence of the variables in these two districts. So, regional variations and local-level specificities are also important to understand the technology adoption process and devising an agriculture extension strategy.

Overall, the discussion showed that the technology adoption process is determined by various factors, but farmers in the smallholding farming context choose to maximize utility. In addition, some variables have special attributes that can disproportionately influence the adoption process of agricultural technologies.

CHAPTER VI

SUMMARY, CONCLUSION AND IMPLICATIONS

This final chapter presents a summary of the study, theoretical significance and implications of the study. The summary section discusses the main findings related to the significant independent variables and their level of contribution to technology adoption and the role of formal education in human capital formation. In the theoretical significance section, four major implications are presented and briefly discussed to show how they contribute to contemporary theoretical knowledge base. Based on the findings of the study, a technology adoption model has been proposed focusing on the role of education in technology adoption. After this, the conclusion of the study is presented and the last section provides implications of the study findings on policy, practices, and research themes.

Summary

More than two-thirds of people are involved in agriculture for their livelihoods and the agriculture sector contributes more than one-third to national GDP in Nepal. But, the agricultural growth rate is very low compared to other sectors. There are various drivers of change for agriculture, and they include rapid land use change, out-migration, climate change, increasing food demand, and land degradation among others. These change processes have posed critical challenges in the agriculture sector, which have negative impact on farmers' livelihoods, national food security, and international trade. Greater adoption of improved agricultural technologies can be an important strategy to address these challenges.

But, agricultural technology adoption rate is considerably low in Nepal. Despite several efforts to promote agricultural technologies, huge financial investment in research and development, and potential high returns from new technologies, there is a profound adoption gap among smallholder farmers. This invites some research questions, i.e., why technology adoption is so low in agriculture and what could be the major determining factors for agricultural technology adoption for smallholder farming in Nepal.

This study therefore explored the major determinants of technology adoption. Two agricultural technologies, i.e., embodied (improved rice variety) and disembodied (integrated pest management) were selected for the study. Based on the literature review, some relevant independent variables were selected and they included ethnicity, age, gender, formal education level, farm size, on-farm annual income, media, non-formal education, informal education through participation in local groups, access to agricultural loan from banks, access to market, access to extension services, cost of technology, economic benefits, non-economic benefits, and ease of use of technology. Hypotheses were developed based on the relevant literature review.

The post-positivist based cross-sectional survey method was employed in this study to objectively analyse the technology adoption process and to identify the major determinants of technology adoption in rice production. Two representative districts were selected for the study through multi-stage sampling method and sample households were selected through random sampling method. Altogether 538 households were interviewed. Data were analysed using SPSS version 20. Logistic regression and descriptive statistics were employed to assess the direction and level of influence of the explanatory variables over the dependent variables and to test the hypotheses. The major findings of the study are briefly presented below.

Major Determinants of Technology Adoption

The significantly influencing factors for the adoption of improved rice varieties (embodied technology) in the research area were age (B= - 0.038) and formal education of respondents (B = 0.089), farm size (B = 0.040), informal education/group participation (B = 1.184), economic benefits (B= 1.282) and non-economic benefits of technology (B = 1.131). The data analysis also showed the relative influence of variables on technology adoption. This analysis revealed that technological attributes (economic and non-economic benefits) were the main determining factors, followed by education (formal and informal). Similarly, farm size was found to have medium level of influence, whereas age had a negative relation.

Similarly for IPM, the significantly influencing variables were ethnicity (B = -1.576), gender (B = -1.481), non-formal education (B = 1.671), informal education (B = 1.163), access to extension (knowledge) services (B = 1.325), and perceived non-economic benefits (B = 2.119). The three important explanatory variables for IPM adoption were non-economic benefits (i.e., perceived impact on human health), non-formal education, and access to extension services. Women and BCT were found to be receptive to technology adoption. Hence, the main determinants for both types of technology were related to technological attributes (both economic and non-economic) and education.

Type of Technology and Education

Education type has differentiated effects based on the type of technology. Data analysis showed that adoption of embodied technology was highly influenced by formal education, whereas non-formal education influenced the adoption of disembodied technology. The main reason for statistically significant influence is attributed to the epistemic value and pedagogic process of education (i.e., formal and non-formal) that are inherently associated with the varied requirement of technology (i.e., embodied and disembodied) to be adopted.

Formal education increases cognitive ability and abstract reasoning. These attributes presuppose more analytical assessment and logical reasoning ability of farmers, which is required for adoption of embodied technology, whereas non-formal education helps to increase the practical skills and competency of farmers to perform specific tasks through dialectic and deliberative processes that are necessary for adoption of disembodied technology.

Role of Formal Education in Human Capital Development

The study tested the role of formal education in human capital formation by considering adoption of improved rice variety in farming. Two constructs of human capital, i.e., work effect and allocative effect (Welch, 1970), were assessed through improvement in rice productivity and overall technology adoption. The simple regression analysis showed that one unit of change in formal education has significant influence ($p=0.000$) in productivity enhancement. The data showed that the odds of increasing productivity for one year increase in formal education is 15% ($b = 0.141$, $EoC = 1.152$).

In the case of allocative effect, it is expected that farmers take appropriate decisions considering the input-output relation from the best options available. In this case, multiple regression showed that formal education is statistically significant with the improved rice variety adoption ($p = 0.024$) and the marginal change (one year change) in formal education would increase technology adoption by 9%.

Similarly, the education categories (primary, secondary, and higher) showed higher ‘allocative effect’ with higher level of education of farmers. A multivariate regression of education categories showed that the odds of adopting improved rice variety by respondents with secondary and higher education are 1.8 and 5 times the odds of respondents with primary education. The findings showed farmers with higher education have greater allocative ability so that they can adopt technology.

Theoretical Significance of the Study

The study derives four theoretical learning which are relevant to agricultural technology adoption in Nepal and to enrich the agricultural technology adoption literature. They are: i) the role of utility maximization theory to explain the adoption process in the Nepali farming context; ii) the intrinsic nexus of education with the type of agricultural technology; iii) the role of formal education in enhancing human capital of farmers; and iv) possible categorization of explanatory variables according to the type of agricultural technology

Utility Maximization Theory

In Nepal, farmers mostly follow subsistence-oriented farming systems and the market is generally imperfect. This means farmers do not get accurate, precise, and timely information to choose the best suitable options from the pool of alternatives. The situation is further challenging for the farmers who live in remote areas and do not have adequate access to basic services. In addition, due to uncertain climate and unregulated market, farmers face a lot of stochastic production and management risks, and they have less control on those risks. Hence, as part of the risk minimization strategy, they prefer to explore multiple benefits from new technologies. While exploring multiple benefits, they undertake some trade-off of benefits such as economic versus non-economic benefits.

In this study, both economic and non-economic benefits were equally emphasized by the farmers. In the case of rice, both perceived economic and non-economic benefits influenced technology adoption. For IPM, perceived non-economic benefits were one of the major determining factors. The result showed that farmers were sensitive in terms of human health, and they believed IPM products helped to improve human health.

This trade-off between the benefits is well described by technology adoption behavioural theories such as the theory of planned behavior (Ajzen, 1991; Venkateshet al., 2003; Hernadez & Mazzon, 2006). For example, the attitude towards the behaviour, the first construct of the theory of planned behaviour, is defined as a positive or negative feeling on technology adoption, which is determined through an assessment of farmers' beliefs regarding the consequences of technology adoption. In this case, farmers' beliefs showed that having good quality rice straw and healthy food for their own consumption were important factors in enhancing their livelihoods, and these aspects were fully considered while adopting new technologies.

The study found that the simplistic notion of 'economic rationale' for technology adoption may not work in smallholding farming context, and both economic and non-economic benefits played important role in technology adoption. This finding is in line with the findings another study carried out in Nepal by Thapa (2008). Hence, it is clear that the theory of utility maximization has better ability, compared to economic theory, to explain the technology adoption process in the Nepali context.

Education and Technology Nexus

The second major finding is related to the embedded connectedness of education with agricultural technologies. The role of education was positive in this study, but further analysis showed that the type of technology (embodied and disembodied) was found to be sensitive to the type of education received by the farmers.

Formal education and embodied technologies. The earlier chapters discussed the two learning outcomes of formal education. They are: enhancing cognitive ability and developing the skills of students and farmers. Cognitive ability is developed by remembering, understanding, and using information (Perkins, 1992). In ideal situation, school work focuses on understanding, organizing the lesson content, and makes information meaningful for the future (Hopper & Rieber, 1995). For making the information meaningful, selection, organization, and integration of information are required (Mayer, 1984). In addition, formal education helps formation of general skills through literacy and numeracy. Literacy enables farmers to follow written instructions such as how to use IPM technology in the field, whereas numeracy allows them to calculate accurate dosages of bio-pesticides and facilitates them in making planning decisions (Appleton & Balihuta, 1996).

As discussed earlier, embodied technology is in physical form, has proprietary nature, is simple to use, easy to transfer (scale-friendly) through individual initiative, but it needs some strategic and logical thinking, and rational scrutiny by individual farmers for proper selection of technology. An individual farmer should also be ready to take the risk of adopting the technology. For example, in order to choose new rice varieties, farmers have to explore through their own personal initiatives, test and evaluate new technologies. For this, the farmers may have to visit agro-vets and DADOs to know about the recent rice varieties. There are many rice varieties available based on productivity, time for maturity and suitability according to geographic conditions, among others; so, farmers have to choose one variety from among various options by using their knowledge taking into account possible costs and benefits.

In this case, choosing variety or new technology is an individual decision taken by a farmer and the selection process requires special capacity and ability, which can be attained through formal education, especially through its two learning outcomes, i.e., cognitive ability and enhancing skills. Based on the findings of the study, as discussed above, formal education, therefore, support adoption of embodied technology.

Non-formal education and disembodied technology. Non-formal education processes effectively use critical pedagogy and innovative approaches (Delors, 1996). In this case, the knowledge is shared with farmers through a dialectic process and practical classes (on-the-job training) to solve specific problems related to agriculture. Non-formal education also follows the self- learning with critical reflection processes (Brookfield, 1986) that are useful for disembodied technology adoption.

The cognitive domain of non-formal learning is about how farmers can gain knowledge and the psycho-motive domain deals with skills (Odeyemi, 2003). According to these two constructs, it is important that farmers should be considered as independent agents who need to get appropriate knowledge and enhance their ability to adopt technology and practical skills. Non-formal education provides opportunities to farmers to acquire new knowledge and hands-on practical skills through field demonstrations. The affective domain focuses on attitudinal change of farmers as they generally have their age-old beliefs through acculturation and belief systems, and non-formal education best serves this purpose by organizing farmer groups and knowledge-sharing among peers.

Disembodied technologies, as described in Chapter V, are generally a package of process/idea-focused technologies that have ‘public goods’ nature. The technologies are generally promoted through collective actions and are facilitated by individual experts or a team of experts. The IPM technology is a package of ‘processes and technologies’ used to control insects and pests in rice farms. The specific technologies include, for example, biological, physical, and chemical measures for controlling insects harmful to rice plants. But, it is important for farmers to know the economic threshold level before choosing specific control measures for harmful insects. For instance, for using chemical control measures, farmers should consider economic threshold of damage made by insects.

Hence, farmers require some technical knowledge and skills to adopt IPM. The technical competency may include proper judgment ability of farmers to take appropriate decision based on the field problem (cognitive domain) and skills such as to use chemical control measures (psycho-motive domain). It is also important that farmers also work with group members in a collaborative way (affective domain). These attributes which required adoption of disembodied technologies can, in fact, be better provided by non-formal education.

The analysis showed that there is clear resonance between formal education and embodied technology and between non-formal education and disembodied technology. But these relations are not explicitly documented in the existing agricultural technology adoption literature. So, it is expected that this analysis will help to bring new knowledge in agricultural technology adoption and provides some new theoretical knowledge to the existing literature.

Education, Human Capital and Embodied Technology Adoption

Since the pioneering works of Schultz (1961) and Nelsons and Phelps (1966), the role of education in human capital formation and technology adoption has become an important consideration. Nelson and Phelps (1966) argue that the role of human capital in development may go beyond as a mere factor of production.

This study showed the positive contribution of formal education to human capital development of farmers. The rice productivity (work effect) of higher educated farmers was found to be greater than the farmers with lower education level. For instance, the rice productivity analysis according to education categories, i.e., primary, secondary and higher education, also suggested that farmers with higher education had higher productivity (3.64 MT/ha), whereas secondary and primary education groups had 3.58 and 3.5 ton/ha respectively. Similarly, the adoption rate for educated farmers was higher (allocative effect). It was noticed that one year of additional education had 9% higher adoption rate. In addition, the education categories of farmers also showed that farmers with higher education were more likely to adopt agricultural technology.

This finding of the study corresponds with the findings of an empirical study carried out by Huffman (1990), which showed that education is one of the main factors for increasing human capital. So, the study showed that formal education can contribute to human capital development, as suggested by Schultz (1961) and Nelsons and Phelps (1966).

Typology of Independent Variables according to Type of Technology

Adoption decision theories have been exploring ‘why farmers adopt a specific innovation’ and ‘what are the major variables’. The literature review showed that those variables were categorized according to the ‘origin’ of variables (supply side) such as education, socio-economic and others. But, none or very little information was available on the categories of independent variables according to the type of technology (demand side) to be adopted. The study attempted to classify independent variables based on the demand side, which is expected to bring new knowledge of the agricultural technology adoption process.

Although no empirical evidence is available so far on agriculture, there exist some studies in sociological sciences. For example, in the social psychology tradition, there has been some research on the 'individual' and 'group' responses to development issues and how these levels of 'self' (individual as 'I' and group as 'we') respond to various developmental aspects. According to Brewer and Garder (1996), the individual or personal self compares his or her action with those of other persons and the main motivation is related to self-interest (such as personal benefits or incentives) whereas groups or collective 'self' compare themselves with similar groups and the main social motivation is collective welfare (such as non-economic benefits).

This approach can also be adopted in this study. As discussed in the earlier chapters, the nature of embodied technology is related to private goods (proprietary nature) and developed and managed by private sector or individuals, whereas in the case of disembodied technology, the technology has more of a public goods nature, organizations are involved in promotion and management, groups are involved in execution, and collective actions are required to deliver specific objectives.

The analysis showed that embodied technology has more embedded 'individual' attributes or efforts for production, distribution and use of technology, and the adoption of embodied technology, therefore, is likely to be influenced more by the explanatory variables which have individual attributes (or 'I' self). Similarly, disembodied technology has more embedded ‘social’ or ‘collective action’-related attributes and adoption of this technology is likely to be influenced more by the explanatory variables which have collective or group attributes (or ‘we’ self).

Considering these divisions, the independent variables can be categorized based on their possible contribution to type of technology adoption. They are ‘variables that relate to individual attributes’, ‘variables that relate to social/collective attributes’, and ‘variables that influence both more or less equally’.

In this study, the main influential variables for embodied technology were perceived benefits (economic and non-economic) and personal attributes such as age, formal education and farm size (personal property). These variables are more associated with individual knowledge, skills, efforts and property which can logically be grouped under ‘individual attributes’. Whereas disembodied technology was found to be mostly influenced by gender, ethnicity, non-formal education and perceived benefits (non-economic – human and environmental health) which are more compatible with group approach and collective welfare. As discussed earlier, gender and ethnicity are mainly social constructs determined mainly through historical knowledge systems and existing society. Similarly, participation in field demonstration for IPM is mainly a group approach. So, these variables can logically be grouped under ‘social attributes’. The analysis, therefore, showed that there are embedded connectedness between independent variables according to the type of technologies. So, based on these relations, independent variables can be categorized.

It is, however, a challenging task to perfectly categorize the independent variables based on these criteria. The demarcation is still blurred and can be contested due to some conceptual overlaps, but the analysis tries to show some logical divisions and explanations to justify the categorization. A detailed empirical study, therefore, may help to further explain the relationships. This categorization may have an enormous implication for defining and exploring the agricultural technology adoption process from both theoretical and operational points of view.

In short, from theoretical point of view, this research has helped to understand the factors affecting agricultural technologies in the small farming context in Nepal. The research showed four major findings, which require some theoretical discussions and have practical implications. The utility maximization theory better explains farmers' technology adoption process. Embodied and disembodied technologies are influenced by formal education and non-formal education respectively, and they have some embedded connectedness. Based on the literature review, these relations can be considered as new knowledge to the existing agriculture adoption literature. The study also showed that formal education enhances human capital, which confirms the theoretical relations as suggested by earlier studies. The last finding is about categorization of independent variables based on the type of technology (demand side). The analysis showed some logical connections and explanations to group the variables based on their possible influence on the type of agricultural technology. But, this may need further verification.

Model for Agricultural Technology Adoption

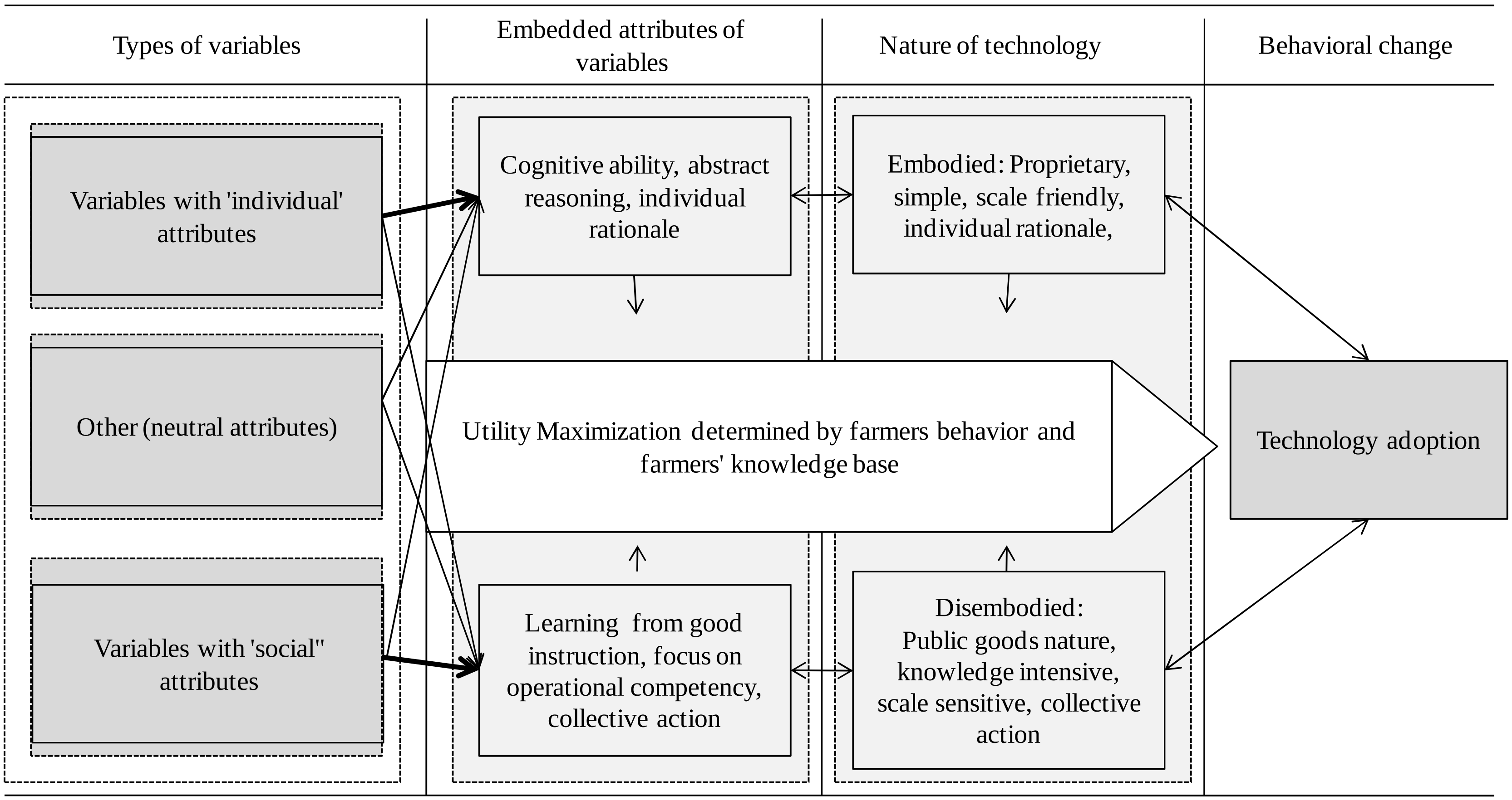
Based on literature review, a conceptual framework was prepared to guide the study. The framework helped to identify and assess the major independent variables for technology adoption. But, given the intrinsic relationship of education with the type of technology and their possible roles in technology adoption in the Nepali farming systems, there is a need to clearly reflect on the relations in the technology adoption process. Hence, based on the findings of the study, a technology adoption model is proposed that can better explain the embodied and disembodied agricultural technology adoption processes, which can be useful in the similar small farming context in Nepal. Some important components of the model are exhibited in Figure 5 and they are also briefly described below.

Based on the findings of the study, three categories of variables are proposed, considering their potential influence on the adoption of agricultural technology. The first group or ‘individual attributes’ includes explanatory variables such as formal education, economic benefits, farm assets, and age of the individual. These variables contribute to support individual innovation or efforts which resonate more with the requirement of smooth adoption of the embodied technology.

The second group or ‘social attributes’ includes explanatory variables such as non-formal education, ethnicity and gender, which are more related to social or collective innovation. These variables support social or collective welfare more and they are supportive to easy adoption of disembodied technology. The third group or ‘equal influence’ is related to socio-economic status, informal education, and enabling environment, which impact technology adoption, but they have similar level of influence on both types of technologies.

It was also shown that the groups with ‘individual attributes’, such as farmers’ formal education, are likely to develop cognitive ability and abstract reasoning through active construction of knowledge and influence individual ability to take the risk of adopting new technology and these attributes are appropriate for embodied technology adoption. Whereas variables with ‘social/collective attribute’, such as non-formal education, are more associated with generating operational competency, following collective action through interactive learning process, and spreading innovation or risks among group members, and these characteristics are suitable for adoption of disembodied technology.

5. A Proposed Agricultural Technology Adoption Model for the Farming Context Similar to the study



This is a proposed model of technology adoption in similar contexts in Nepal considering the two types of technology adoption in the two districts. Although the study has not considered broader issues such as subsidy, international trade and other factors such as irrigation facility, availability of chemical fertilizers, based on the analysis of the study, the model can be useful to explain and promote the technology adoption process in the similar types of small-scale farming context in Nepal.

Conclusion

The study has come up with some specific conclusions from the analysis of the study findings and available literature. They are presented below.

i) Extended utility maximization framework is useful to explain agriculture technology adoption process in Nepal

The study reveals that farmers adopt agricultural technologies to gain more utility or benefits from new agricultural technologies. The perception of gaining utility is determined by the farmers' behavior which is determined by farmers' attitudes towards the technologies, subjective norms, perceived control behavior, and individual knowledge base of farmers. Hence, a broader utility maximization based framework integrating behavioral and human capital aspects can be instrumental to explain existing complex agriculture systems and to promote agriculture technology adoption in Nepal.

ii) Pedagogy plays a critical role in adopting the types of agricultural technologies

The study reveals the plausible embedded relations of formal education with embodied technologies, and non-formal education with disembodied technologies. The relations are mainly attributed to the difference in pedagogic process of formal and non-formal education systems as they have unique ways in which content knowledge is conveyed to learners in specific setting. So, these differential effects of pedagogic process of education systems to the types of agricultural technologies have to be considered for better technology adoption.

iii) Formal education can enhance agriculture adoption in the changing context and transform agriculture sector

While there are some limitations and challenges in existing formal education systems in Nepal, the study showed a positive contribution of formal education in human capital formation – both in work effect and allocative effect. Hence, broader understanding of the contribution of formal education on managing uncertainties and improving farmers' efficiency in agriculture development process has to be enhanced and systematically integrated in agriculture education and extension systems in Nepal.

Implications for Policy, Practice and Research

This study is not exhaustive. Based on the findings and conclusion of this study, the following areas can be explored further:

Policy

a) The influential variables identified by the study can be considered while revising the existing agricultural extension strategies; and
b) Based on the findings of the study, the Agriculture Development Strategy (ADS) and the agriculture extension strategy can focus on the specific role of education and human capital to promote effective technology adoption in Nepal.

Practice

a) The agriculture extension programme may train its staff and inform stakeholders on the specific nature of the technology adoption process in general and the type of technology specifically; and

b) The extension strategy and agriculture programme may consider the local-level needs and specificities such as farming systems, farmers' individual attributes, type and level of education, socio-economic status of farmers, and what they expect from new technology (utility) before designing and implementation of extension programmes, instead of thinking linearly and planning at central level.

Research

a) Further research is needed to understand the embedded connectedness between the types of education and the types of agricultural technologies;

b) Further systematic research is needed to better explain the nexus among education – human capital – technology adoption, especially to understand how formal education contributes to farmers work and allocative effects. Role of curricula and classroom practices is equally important to enhance human capital so these issues need to be studied;

c) The study had limited scope. So, a wide range of explanatory variables could not be included in this study despite their potential role. It is, therefore, important to have further studies by including various important factors such as agriculture subsidy, access to various types of resources, and international trade. In addition, the study dealt with rate of adoption of a specific period through a cross-sectional study. Considering the role of diffusion among the smallholding farmers over the period of time, further study on technology diffusion is also needed; and

d) The study has provided analytical synthesis at study sites and district levels, but it did not conduct analysis at VDC level. It is important to carry out further research in order to capture local-level contextual issues and specificity.

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ANNEX

Annex 1

Questionnaire

Contribution of Education in Technology Adoption

> This questionnaire is designed to solicit your responses on factors affecting Integrated Pest Management techniques in rice production. Your responses will be used for academic purposes only and are kept confidential. Please take time to answer these questions. Please feel free to ask survey conductor if you have questions about these questions.

Identification of questionnaire: Name of the respondent: …………………………

District:_____VDC/Municipality:______WardNo:____Village/tole:_________________

Respondent No/ ___________

Date of interview (dd/mm/yy):__/___/__ Name of the interviewer: _________________

A. Personal information/demography

1. Age in years: [ ]

2. Marital status

Single
Married
Divorced
Widow
Other

3. Gender: M F Other

4. No of people in the hhs

	Female	Male	Total
<16			
16-60			
> 60			
total			

People staying with you right now: [ ]

B. Education

5. How many years of schooling did you and your family members complete?

Level of education upto SLC Inter Bachelor Master Other

You	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Literate	Illiterate
Your Spouse	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Literate	Illiterate
Father	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Literate	Illiterate
Mother	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Literate	Illiterate
Son	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Literate	Illiterate

Daughter	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Literate	Illiterate
Other 1…	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Literate	Illiterate
Other 2 ….	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Literate	Illiterate

If you have intermediate degree or more pls provide faculty:

Agriculture	commerce	Humanity	Science	Other

C. Economic condition

6. How much land your family owns?

Upland		***Lowland***		***Other***		***total***
Kathha		Kathha		Kathha		
Ropani		Ropani		Ropani		

7. What are main crops (in Kathha or Ropani)

Crop	Rice	Wheat	Maize	Vegetable	Other
Priority					

8. What are the three main cash income in your family last year (2069)

Source	Agri - crop	Livestock	Vegetable	off farm job	Business	Remittance	other
Contribution %							

Rice farming and IPM

9. How many years of experience do you have in rice farming. Write in years: ……..

10. Do you know IPM? Yes…. No………

11. When did you first adopt the IPM technology?

…within 5 yrs; ….5-10 years ……..> 10 years …….No adoption

12. If you have discontinued IPM- how many years you practiced? ………..years (write in years)

13. Are you a primary decision maker in rice farming: ….Yes …….NO

14. Who helps you the most in farming decision making process? Father/mother/spouse/ Son/daughter

15. Please mention the size of area under each category you have planted rice in this season.

Land tenure system	Own land	Share cropping	Lease in	Total
Rice cultivation area (Ro/Ka)				

16. Do you know about improved rice varieties ? …….yes ……..no

17. Do you use (adopt) new improved varieties of rice in last 3 years? ..yes ..no

18. Do you use IPM technology in rice in last 3 years? …….yes ……..no

19 What is cultivation area, source of seed and time for improved Rice var?

		Seed source				
	Local unit (ka/Ro)	own	outside	own seed use duration (yr)	If from outside how many yrs	Improved var: those which are released by NARC
Local varieties……..						local varieties - used by farmers traditionally
Improved var 1…						
Improved var 2…						
Hybrid 1………..						
Hybrid 2………						

20. Why you use new improved varieties of rice. What are the reasons?

	Productivity/ economic		Technological attributes		Resource / environment		Enabling environment		
1	high productivity/benefits	5	not expensive	9	Require less water	13	suggested by friends	17	Access to credit
2	Good market price	6	Good taste	10	appropriate to my area	14	Group suggested	18	Access to extension service
3	Other ……………….	7	by products i.e. straw	11	Adjusting temperature	15	Media (radio / TV)	19	Access to market

4	Other ……………….	8	Easy to use	12	Other….	16	Training on technology	20	Other

21. Among five you mentioned above could you pls provide them in priority order

Priority	First	Second	Third	Fourth	Fifth
Reason no					

22. If you grow local varieties of rice or don't adopt new /improved var- could you pls provide reasons?

1	Inadequate knowledge, no other source of information/ weak extension on improved var	5	Need high level of input (costly)
2	no peers/neighbour are doing improved var	6	Locals var have good scent, good taste
3	they are tolerant to local condition	7	other local utility (e.g. more straw)
4	expensive technology	8	other (pls specify)………………

23. If you have followed the IPM pratices - what types of practices you have followed in rice insect management.

Name of insects:	Types of IPM technology			
Gandi bug	1	2	3	4
Hopper	1	2	3	4
borer	1	2	3	4

1. mechanical/cultural
2. chemical and cultural both
3. other (biological)
4. did nothing - as there was no serious impact)

24. Reasons for adopting IPM

Productivity/economic	attributes of technology	Environmental factors	support systems	
1.improve in production/benefits	5. not expensive	9. suitable in changing rainfall pattern	13. suggested by friends/peers	17. Access to credit

2. Good market price of IPM products	6. safe to human and environment	10. appropriate to changing temp pattern	14. Group suggested	18. Access to extension service
3. reduce cost of production	7. Easy to use	11. Resilience environment	15. Media-radio/TV/newspaper	19. Access to market
4. other……………	8. IPM products tasty	12. other……	16. Training on new technology	20. other………

25: Among five you mentioned above could you pls provide them in priority order

Priority	First	Second	Third	Fourth	Fifth
Reason nos					

26. Reasons for not adopting IPM technology

1	Not effective immediately
2	Tedious/ not easy to perform
3	inadequate knowledge to manage the technology
4	No additional (premium price)

5	Not easy to perform
6	Need community approach;
7	others ....

27. If you have discontinued praticing IPM - could you pls provide reasons

1 too much hassle　3. do not have enough time　5. too coslty

2. not profitable　4. happy with current technology　6. others

28. Do you considered yourself as an innovative farmer? ..Yes　..No　..Don't know

if yes, which category are consider yourself?

1. innovative/always first,　3. interested when my innovative peers did

2. early adopter / with a few colleagues　4. Followed when other villagers adopt

29. Do you want to be innovator? What is reason behind that? If yes, how and why?

1	want to lead in this area / for role model	4	I want to contribute to my communities/societies
2	I want to be enhance farm productivity (improve productivity/efficiency)	5	Responsibility to nature/society
3	I want to practice what I learn (coding, decoding)	6	other…………………………………

30. Do you have water / irrigation facility for timely rice plantation?

…..Good; ...Not reliable ; …Moderate; …Very difficult

31. What is rice productivity status in your farm?

	local unit	Amount	ton /bigha
Improved			
Hybrid			
Local			

Knowledge management and practices (non formal and informal education)

32. What are the main sources of information/knowledge on new / improved rice varieties? Pls identify main four and prioritize them.

Priority order: 1st, 2nd, 3rd,

	Priority order		
Sources	New rice varieties	IPM	Remarks
Government (DADO)			
Non government (NGOs and local groups)			
Media (FM, radio and newspaper)			
Informal groups (peer and relatives)			
Exposure visits			

Private companies			
Formal education			
Other			

33. Did you receive any training on rice cultivation in last 2 year? …..Yes …..No

If yes, pls tell

Training types	1	2	3	4	Improved seed- 1, IPM – 2, General Agriculture – 3, Vege- 4
No training	1	2	3	4	
Training provided by	1	2	3	4	1 DADO 2 - NGO 3- Local groups 4 other

34. Have you involved in any on-site result demonstration of rice varieties and IPM ,…Yes ….No

35. Have you been involved in community / social groups related to farming and livelihoods in last two years, ,…Yes ….No,

If yes

Types of community (social organizations)	Nature of involvement	
Farmers groups (DADO, Livestock, NGOs)/	1	2
Saving Credit group/ NGO group/cooperative	1	2
Natural Resources management groups (i.e. CFUGs, irrigation)	1	2
Socio-political group (VDC, school, political party etc)	1	2

N. B. : 1. General member, 2. Executive role

36. How many times do you attend meetings (related to rice varieties and IPM) during last year? <10 10 to 20 > 20

37. Do you ever apply for loan for crop production? ….Yes …..No

38. How easy to get agricultural loan:

From coops/ local S/C groups:

….very easy ….Easy ..Difficult ..Very difficult

From Banks:

…..very easy …..Easy …..Difficult ……Very difficult

39. How far is your farm from market (district headquarter)

…in 5 Km ….in 15 Km …more than 15 Km

40. How far is often you visit government agri technician in a year:

… No visit …less than 5 …more than 5 times

41. Do you know about the impact of insecticide/pesticides?

…..Yes….No …Don't know

42. Do you think chemicals can cause sickness to humans?

…..Yes ….No …Don't know

43. Do you think chemicals can cause sickness to other living organisms?

...Yes ….No….Don't know

45. Do you have experience following climatic changes?

	Change	No change		If changes - what are the variability			
Precipitation patterns				late monsoon	increased drought	extreme rain in short period	Other
Change in temperature				Rise	down		

46. What impacts were seen from these changes?

	Increased	Same	Decreased
Crop productivity			
Insect/pest			
Off farm activity			

47. What types of varieties are needed to address these challenges?

	Tick appropriate one
Short duration	
good productivity	
Drought resistance	
Insect / pest resistance	
Other (pls specify)	

Please give your opinion regarding your attitude towards cultivating new/improved rice by putting a check mark in one of the columns that fit best.

1. Fully agree; 2. Agree; 3. Neutral; 4. Disagree; 5. Completely disagree

Technological attributes new varieties [attitudes (A), Percieved Usefulness (PU), Ease of Use (EU) and social influence]

Following factors affect in adopting of improved/new rice varieties

48	To adopt new rice varieties, seed price is important for me	1	2	3	4	5
49	To adopt new rice varieties, water requirement is important for me	1	2	3	4	5
50	To adopt new rice varieties, possible market price is important for me	1	2	3	4	5
51	To adopt new rice varieties, straw quantity /quality is important for me	1	2	3	4	5
52	To adopt the new var, taste and other quality are important	1	2	3	4	5
53	To adopt new rice varieties, susceptibility to insect and pest is impo for me	1	2	3	4	5
54	To adopt new rice varieties, it important to reduce labor requirement	1	2	3	4	5
55	To adopt new varieties, it should increase my prestige among my peers	1	2	3	4	5
56	Media is important for the technology adoption	1	2	3	4	5

57	To adopt new varieties, the var should have higher productivity	1	2	3	4	5
58	To adopt new varieties,(short) duration of crop maturity is important for me	1	2	3	4	5
59	To adopt new varieties, it should be easier to grow	1	2	3	4	5
60	To adopt new varieties, it should improve my livelihoods	1	2	3	4	5
61	To adopt new varieties, I fully trust my friends and group members	1	2	3	4	5
62	To adopt IPM, cost of new technology is important for me	1	2	3	4	5
63	I am adopting IPM because I am aware of my health	1	2	3	4	5
64	I am adopting IPM because I am aware of beneficial insects and my environment	1	2	3	4	5
65	It has been difficult to adopt IPM because it is tedious and difficult to handle	1	2	3	4	5
66	It has been difficult to adopt IPM as I am not getting fair price on IPM products	1	2	3	4	5
67	It has been difficult to adopt as it is long /slow process of controlling insects	1	2	3	4	5
68	It is difficult to adopt as it needs a community approach	1	2	3	4	5
69	I know managing IPM needs more knowledge	1	2	3	4	5
70	IPM has been useful for my livelihoods	1	2	3	4	5
71	To adopt IPM, I fully trust my friends and group members	1	2	3	4	5

THANK YOU VERY MUCH - THE END

Annex 2

Basic descriptive data of the study

Basic/descriptive data of embodied technology (Improved Rice Variety)

Frequency table of categorical valuables

Variables		Adoption of improved rice var in last 3 years by the respondent							
		No adoption				Adoption			
		Kavre		Chitwan		Kavre		Chitwan	
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
Ethnicity of respondents	Bramin Chetteri and Thakuri	60	74.1%	21	25.9%	171	54.6 %	142	45.4 %
	Janajati	17	45.9%	20	54.1%	40	40.4 %	59	59.6 %
	dalit and others	0	0.0%	2	100.0 %	0	0.0%	4	100. 0%
Gender of respondents	female	33	75.0%	11	25.0%	112	50.9 %	108	49.1 %
	male	44	57.9%	32	42.1%	100	50.8 %	97	49.2 %
Age of respond	less than 25 years	1	100.0 %	0	0.0%	22	37.9 %	36	62.1 %

Variables		Adoption of improved rice var in last 3 years by the respondent							
		No adoption				Adoption			
		Kavre		Chitwan		Kavre		Chitwan	
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
	from 26 to 40 years	18	69.2%	8	30.8%	87	55.1%	71	44.9%
	from 41 to 55 years	33	63.5%	19	36.5%	75	54.3%	63	45.7%
Education of respondents	primary (1-5 class)	54	59.3%	37	40.7%	109	59.2%	75	40.8%
	secondary upto 12	22	78.6%	6	21.4%	94	45.0%	115	55.0%
	higher education	1	100.0%	0	0.0%	9	37.5%	15	62.5%
Contribution of media in technology adoption	no	51	55.4%	41	44.6%	118	38.3%	190	61.7%
	yes	26	92.9%	2	7.1%	94	86.2%	15	13.8%
Training	no	44	52.4%	40	47.6%	73	27.2%	195	72.8%

Variables		Adoption of improved rice var in last 3 years by the respondent							
		No adoption				Adoption			
		Kavre		Chitwan		Kavre		Chitwan	
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
	yes	33	94.3%	2	5.7%	139	93.3%	10	6.7%
involvement in groups rice only	no	28	59.6%	19	40.4%	21	31.3%	46	68.7%
	yes	48	66.7%	24	33.3%	189	54.5%	158	45.5%
Loan taken by respondents for agriculture	no	51	55.4%	41	44.6%	114	36.3%	200	63.7%
	yes	25	92.6%	2	7.4%	94	94.9%	5	5.1%
Distance of market for the farmer	less than 5 km	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	-5-15 km	33	55.9%	26	44.1%	100	41.7%	140	58.3%
	more than 15 km	44	72.1%	17	27.9%	112	63.3%	65	36.7%
Role of seed cost	no	51	70.8%	21	29.2%	131	55.5%	105	44.5%
	yes	26	54.2%	22	45.8%	81	44.8%	100	55.2%
Role of non-	no	31	73.8%	11	26.2%	22	45.8%	26	54.2%

Variables		Adoption of improved rice var in last 3 years by the respondent							
		No adoption				Adoption			
		Kavre		Chitwan		Kavre		Chitwan	
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
	yes	46	59.7%	31	40.3%	190	51.5 %	179	48.5 %
Role of ease of use	no	3	25.0%	9	75.0%	5	8.6%	53	91.4 %
	yes	74	69.2%	33	30.8%	207	57.7 %	152	42.3 %
Role in economic benefits (livelihoods)	no	24	54.5%	20	45.5%	10	24.4 %	31	75.6 %
	yes	53	74.6%	18	25.4%	202	53.7 %	174	46.3 %

Ethnicity distribution and adoption (IRV)

	BCT		Magar, Gurung, Tamang, Rai		Darai, Tharu		Dalit and others	
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
no adoption	85	71.4%	23	19.3%	9	7.6%	2	1.7%
adoption	315	75.5%	44	10.6%	54	12.9%	4	1.0%

Frequency table of continuous variables

Research sites

	N	Minimum	Maximum	Mean	Std. Deviation
Age of respondent	538	16	85	43.37	13.337
Education of respondent	538	0	17	5.22	4.764
total land in Kattha	538	1.00	70.00	14.6362	10.41958
contribution from farm in annual income of the family in percentate	534	10.00	100.00	78.5019	20.73696
Education of respondent's spouse	497	0	17	4.65	4.935

Kavre

	N	Minimum	Maximum	Mean	Std. Deviation
Age of respondent	290	20	85	43.67	12.921
Education of respondent	290	0	16	4.60	4.748
total land in Kattha	290	3.01	66.22	15.7613	9.74799
contribution from farm in annual income of the family in percentate	286	10.00	100.00	85.6643	17.39871
Education of respondent's spouse	288	0	15	4.21	4.831

Chitwan

	N	Minimum	Maximum	Mean	Std. Deviation
Age of respondent	248	16	77	43.02	13.825
Education of respondent	248	0	17	5.96	4.687
total land in Kattha	248	1.00	70.00	13.3206	11.02863
contribution from farm in annual income of the family in percentate	248	20.00	100.00	70.2419	21.23090
Education of respondent's spouse	209	0	17	5.25	5.024

Basic/descriptive data of disembodied technology (IPM)

Frequency table of categorical valuables

		Adoption of IPM in rice in last 3 years by the respondent revised							
		no adoption				adoption			
		Kavre		Chitwan		Kavre		Chitwan	
Variables		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
Ethnicity of respondents	Bramin Chetteri, and Thakuri	106	62.4%	64	37.6%	125	55.8%	99	44.2%
	Janajati, newar, dalit and others	41	42.7%	55	57.3%	17	36.2%	30	63.8%
Gender	female	46	60.5%	30	39.5%	99	52.7%	89	47.3%
	male	101	53.2%	89	46.8%	43	51.8%	40	48.2%
Age of	less than	4	50.0%	4	50.0%	19	37.3%	32	62.7%

Variables		Adoption of IPM in rice in last 3 years by the respondent revised							
		no adoption				adoption			
		Kavre		Chitwan		Kavre		Chitwan	
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
respondents	25 years								
	from 26 to 40 years	42	58.3%	30	41.7%	63	56.3%	49	43.8%
	from 41 to 55 years	60	53.6%	52	46.4%	48	61.5%	30	38.5%
	56 and above	41	55.4%	33	44.6%	12	40.0%	18	60.0%
Education of respondents	primary (1-5 class)	89	55.3%	72	44.7%	74	64.9%	40	35.1%
	secondary upto 12	52	57.1%	39	42.9%	64	43.8%	82	56.2%
	higher education	6	42.9%	8	57.1%	4	36.4%	7	63.6%
Participation on field demonstration	no	98	54.1%	83	45.9%	39	57.4%	29	42.6%
	yes	48	57.1%	36	42.9%	103	50.7%	100	49.3%
Invovel	no	67	48.2%	72	51.8%	48	55.2%	39	44.8%

Variables		Adoption of IPM in rice in last 3 years by the respondent revised							
		no adoption				adoption			
		Kavre		Chitwan		Kavre		Chitwan	
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
	yes	74	61.2%	47	38.8%	94	51.1%	90	48.9%
Loan taken by the respondents	no	97	48.3%	104	51.7%	77	43.0%	102	57.0%
	yes	49	76.6%	15	23.4%	61	69.3%	27	30.7%
farmers visit/meet government agricultural technicians	no visit	99	54.1%	84	45.9%	27	38.6%	43	61.4%
	visit	47	57.3%	35	42.7%	115	57.2%	86	42.8%
Cost of technology	no	7	18.9%	30	81.1%	84	68.3%	39	31.7%
	yes	22	35.5%	40	64.5%	51	53.7%	44	46.3%
Non-economic benefit (health impact)	No concern	58	47.5%	64	52.5%	35	48.6%	37	51.4%
	yes - concern	37	62.7%	22	37.3%	106	54.1%	90	45.9%
Easy to perform	no - not easy	56	44.1%	71	55.9%	96	68.6%	44	31.4%

Variables		Adoption of IPM in rice in last 3 years by the respondent revised							
		no adoption				adoption			
		Kavre		Chitwan		Kavre		Chitwan	
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
Economic benefits (livelihoods)	yes - easy	34	60.7%	22	39.3%	42	33.6%	83	66.4%
	no	55	48.2%	59	51.8%	23	31.1%	51	68.9%
	yes	31	44.9%	38	55.1%	116	60.4%	76	39.6%

Ethnicity distribution and adoption (IPM)

	BCT		Magar, Gurung, Tamang, Rai		Darai, Tharu		Dalit and others	
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
no adoption	176	66.4%	50	18.9%	36	13.6%	3	1.1%
adoption	224	82.7%	17	6.3%	27	10.0%	3	1.1%

Frequency table of continuous variables

Research sites

	N	Minimum	Maximum	Mean	Std. Deviation
Age of respondent	538	16	85	43.37	13.337
Education of respondent	538	0	17	5.22	4.764
total land in Kattha	538	1.00	70.00	14.6362	10.41958

contribution from farm in annual income of the family in percentage	534	10.00	100.00	78.5019	20.73696

Kavre

	N	Minimum	Maximum	Mean	Std. Deviation
Age of respondent	290	20	85	43.67	12.921
Education of respondent	290	0	16	4.60	4.748
total land in Kattha	290	3.01	66.22	15.7613	9.74799
contribution from farm in annual income of the family in percentage	286	10.00	100.00	85.6643	17.39871

Chitwan

	N	Minimum	Maximum	Mean	Std. Deviation
Age of respondent	248	16	77	43.02	13.825
Education of respondent	248	0	17	5.96	4.687
total land in Kattha	248	1.00	70.00	13.3206	11.02863
contribution from farm in annual income of the family in percentate	248	20.00	100.00	70.2419	21.23090

Annex3

Regression Analysis for Improved Rice Varieties in the research sites

Explanatory variables	Research areas			Kavre			Chitwan		
	B	Sig.	Exp (B)	B	Sig.	Exp (B)	B	Sig.	Exp (B)
Ethnicity (*BCT*)		.651						.132	
Ethnicity (*Janajati*)	-.111	.731	.895	.240	.614	1.271	-1.300	.044	.272
Ethnicity (*dalit* + others)	-.870	.372	.419				-.471	.710	.625
Age of the respondents	-.038	.003	.963	-.053	.003	.948	-.041	.100	.960
Gender (male)	-.345	.264	.708	.211	.620	1.235	-1.551	.014	.212
Education of respondents	.089	.012	1.09	.024	.599	1.024	.170	.024	1.18
Land size (in *Kattha*)	.040	.013	1.04	.017	.371	1.017	.228	.000	1.25
On farm contribution	.002	.711	1.00	.013	.158	1.014	.020	.183	1.02
Non-formal education	-.281	.388	.755	.249	.503	1.282	-1.204	.266	.300
Informal education	1.184	.000	3.26	1.43	.001	4.190	1.721	.004	5.59

Contribution of media	-.091	.772	.913	.488	.171	1.630	.171	.883	1.187
Access to loan	.010	.976	1.010	.657	.070	1.929	-1.041	.465	.353
Access to market (distance to market)	-.425	.144	.654	-.236	.529	.790	-.412	.502	.663
Cost of technology (seed price)	-.221	.412	.802	-.578	.115	.561	.076	.900	1.079
Non-economic benefits e.g. straw	1.131	.000	3.099	1.499	.000	4.478	.909	.238	2.483
Easy to use of technology (easy to grow and manage)	-.909	.058	.403	.011	.991	1.011	-.131	.858	.877
Economic benefits	1.282	.000	3.605	1.554	.002	4.729	1.225	.028	3.404
Constant	.634	.545	1.88	-2.10	.216	.121	-1.621	.463	.198

a. Variable(s) entered on step 1: EthnicityT, age, GenderT, YouEduT, landcom*Kattha*, OnfarmcontributionT, mediacontriT, trrecidT, InvolvegroupRT, LoantakenT, DisMarT1, SeedprT, StrawqulT, EasegrowT, ImpliveliT.

Regression Analysis for Integrated Pest Management in the research sites

Explanatory variables	Research area			Kavre			Chitwan		
	B	Sig.	Exp(B)	B	Sig.	Exp(B)	B	Sig.	Exp (B)
Ethnicity (*janajati*)	-1.576	.008	.207	-3.470	.023	.031	-1.020	.199	.361
Age of the respondent	-.037	.084	.964	-.054	.218	.948	-.019	.509	.981
Gender(men)	-1.481	.009	.227	-1.569	.169	.208	-1.399	.066	.247
Education of respondents	-.020	.747	.980	-.147	.188	.863	.106	.286	1.112
Land size (in *Kattha*)	-.022	.304	.978	.004	.918	1.004	-.051	.144	.951
On farm contribution to family income	.013	.308	1.013	-.023	.475	.977	.022	.234	1.022
Non-formal education	1.671	.00	5.315	2.565	.01	13.003	1.753	.018	5.77
Informal education	1.163	.02	3.200	.947	.25	2.577	1.564	.039	4.77
Access to loan	.336	.57	1.400	.981	.38	2.668	.216	.835	1.24

Access to agri extension	1.325	.01	3.763	-.739	.54	.477	2.057	.011	7.825
Cost of technology	-.349	.49	.706	.360	.71	1.433	-.332	.651	.718
Perceived non-economic benefits (perceived health impact)	2.119	.00	8.320	2.405	.02	11.078	2.193	.005	8.96
Easy to use of technology (easy to grow and manage)	1.064	.06	2.898	.794	.55	2.212	1.649	.032	5.20
Economic benefits (improvement on livelihoods)	.165	.75	1.179	.730	.49	2.076	.103	.899	1.10
Constant	-.049	.97	.952	5.163	.19	174.61	-3.080	.253	.046

a. Variable(s) entered on step 1: EthnicityT, age, GenderT, YouEduT, landcom*Kattha*, OnfarmcontributionT, DempartT1, InvolvegroupIT1, LoantakenT1, TimetechT1, IPMcostT, IPMhealthT2, IPMtech_easyT1, IPMLiveT1.

Annex 4

IRV adoption models

log(p/1-p) = 1.035 - 0.038age + 0.089YouEduT + 0.040landcomkatha + 1.184involvegroupRT(1) + 1.131StrawqualT(1) + 1.282ImpliveliT(1) …………………1

Where p is the probability of improved rice varieties adoption.

The logistic regression model was statistically significant, chi-square ($\chi^2(16) = 137.231$, $p < .0005$. The model explained 36.3.0% (Nagelkerke R^2) of the variance in technology adoption.

For Kavre, the model is as below:

log(p/1-p) = -0.873 – 0.053age +1.433involvegroupRT(1) +1.499StrawqualT(1) + 1.554ImpliveliT(1) …………………………..…………………………………….2

Where p is the probability of improved rice varieties adoption.

The logistic regression model was statistically significant, chi-square ($\chi^2(15) = 86.837$, $p < .0005$. The model explained 40% (Nagelkerke R^2) of the variance in technology adoption.

For Chitwan, the model is as below

log(p/1-p) = -1.508 – 1.3EthnicityT(1) – 1.551Gender(1) +0.170YouEduT + 0.228landcom*Kattha* + 1.721InvolvegroupRT(1) + 1.225ImpliveliT(1)………………..3

Where p is the probability of improved rice varieties adoption.

The logistic regression model was statistically significant, chi-square ($\chi^2(16) = 97.111$, $p < .0005$. The model explained 59% (Nagelkerke R^2) of the variance in technology adoption.

IPM : adoption model

The analysis derived following adoption model for the research area.

log(p/1-p) = -0.049- 1.576 EthnicityT (1) – 1.481 GenderT (1) + 1.671 DempartT1(1) + 1.1637InvolvegroupIT1 (1) + 1.325TimetechT1(1) + 2.119 IPMhealthT2(1) + 1.064IPMtech_easyT1(1)………………………………………. 4

Where p is the probability of improved rice varieties adoption.

The logistic regression model was statistically significant, chi-square ($\chi^2(14)$ = 149.879.168 $p < .0005$. The model explained 67.7% (Nagelkerke R^2) of the variance in technology adoption.

For Kavre, the model is as below:

log(p/1-p) = 5.163 – 3.470 EthnicityT (1) + 2.565 DempartT1(1) + 2.405IPMhealthT2(1)

Where p is the probability of improved rice varieties adoption.

The logistic regression model was statistically significant, chi-square χ2(14) = 49.539, $p < .0005$. The model explained 60.2% (Nagelkerke R^2) of the variance in technology adoption.

For Chitwan, the model is as below

log(p/1-p) = - 4.1+ 1.753 DempartT1(1) + 1.564InvolvegroupIT1 (1) + 2.057TimetechT1(1) + 2.193 IPMhealthT2(1) + 1.649IPMtech_easyT1(1)

Where p is the probability of improved rice varieties adoption.

The logistic regression model was statistically significant, chi-square (χ2(14) = 93.514, $p < .0005$. The model explained 74.6% (Nagelkerke R^2) of the variance in technology adoption.

Annex 5

Regression analysis of significant variables for IRV in eco-zones

	Kavre			Chitwan		
Explanatory variables	β	Sig.	Exp (β)	β	Sig.	Exp (β)
Ethnicity (*BCT*)					.132	
Ethnicity (*Janajati*)	.240	.614	1.271	-1.300	.044*	.272
Ethnicity (*dalit* + others)				-.471	.710	.625
Age of the respondents	-.053	.003*	.948	-.041	.100	.960
GenderT(male)	.211	.620	1.235	-1.551	.014*	.212
Education of the respondents	.024	.599	1.024	.170	.024*	1.185
Land size (in *Kattha*)	.017	.371	1.017	.228	.000*	1.256
On farm contribution to family income	.013	.158	1.014	.020	.183*	1.020
Informal education (participation in groups)	1.433	.001*	4.190	1.721	.004*	5.591
Non-economic benefits i.e. straw	1.499	.000*	4.478	.909	.238	2.483
Economic benefits (on livelihoods)	1.554	.002*	4.729	1.225	.028*	3.404

** Significant variables*

Regression analysis of significant variables for IPM in eco-zones

	Kavre			Chitwan		
Explanatory variables	*B*	Sig.	Exp(β)	β	Sig.	Exp(β)
Ethnicity (*Janajati*)	-3.470	.023*	.031	-1.020	.199	.361
Non-formal education (participation on field demonstration)	2.565	.012*	13.003	1.753	.018*	5.772
Informal education (participation in groups)	.947	.257	2.577	1.564	.039*	4.778
Access to agri extension	-.739	.545	.477	2.057	.011*	7.825
Perceived non-economic benefits (perceived health impact)	2.405	.023*	11.078	2.193	.005*	8.966
Easy to use of technology (easy to grow and manage)	.794	.556	2.212	1.649	.032*	5.200

** Significant variables*