Doctoral Dissertation

SUSTAINABILITY OF COMMUNITY-BASED RICE SEED PRODUCTION: A CASE STUDY IN THE TARAI REGION OF NEPAL

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Dedication

Dedicated to my most respectable and beloved

father Mr. Churamani Khanal and mother Mrs. Gun Kumari Khanal

Summary of the dissertation

Community-based seed production system is considered to supply diversified rice varieties in rural areas in a cost effective way. Development agencies have been promoting this concept to address poverty, food security and climate change adaptation issues. However, how this system could continue is a contested issue among the researchers and policy makers due to handling of seed production and marketing activities by resource poor farmers without business skills. Very limited studies have been published in this area. This study analyzed the sustainability of this system putting seed producers and seed consumers in the context, and considering three pillars of sustainable development i.e. economy, environmental and social in the analytical framework. How seed producers realize economic benefit and how that benefit continues is the major research question addressed in this study. Here, efficiency of farmers in production and marketing captures the economic issue, and the efficiency is analyzed at two levels: production and marketing. Since seed producers are small farmers, the environmental and social issues are analyzed linking them with economic issue because environmental and social benefits are not easily visible for this category of farmers.

Characteristics of seed consumers play important role in seed demand and thereby economic benefits of seed producers. The seed demand characteristics were analyzed from the perspective of types of rice varieties grown by consumers and their behavior in adopting different rice varieties. Result shows that consumers (farmers) grow both modern and farmers' varieties; however, majority of these varieties have not been registered in the government system.

Farmers buy these varieties from neighboring farmers, agrovet, seed producer organizations and development projects. Farmers' behavior in buying seed from the

market was analyzed using binary logistic regression. Result shows that farmers with higher educated household head, access to irrigation facility and having membership in community-based organizations are more likely to buy seed from the market.

Efficiency of households in producing rice seed was measured for their ability to maximize rice seed yield in utilizing their most commonly used inputs: operational land, source seed, chemical fertilizer, livestock and human labor. Both allocative efficiency and technical efficiency were measured in this study. Allocative efficiency was measured as the ratio of marginal value product of their inputs to their price. The result shows that operational land and human labor are over utilized but source seed and chemical fertilizers are underutilized. The technical efficiency of farmers for utilizing the above-mentioned inputs was measured through stochastic frontier production model. The result shows that households are 81% efficient in utilizing the above-mentioned inputs but there is a quite high variation in the efficiency level among the households. This variation is mainly explained by education of household head, households' experience in rice seed production, and land quality. Land quality is the proxy variable for soil fertility and irrigation facility.

Soil conservation practices contribute in enhancing the land quality by improving soil fertility, and it gives the basis for continuity of economic benefits for long time by minimizing the agricultural impact on air, soil, water and biodiversity. This study shows that famers use animal manure, zero tillage, green manure and improved practice to conserve soil. There is positive linkage between these practices and rice yield as well as technical efficiency of farmers. Factors affecting the adoption of these practices (zero tillage, green manure and improved practice) were analyzed using multivariate probit model because these practices are not mutually exclusive with each other.

In this case, the selected conservation practices were simultaneously modeled with household level demographic, economic and institutional variables. Result shows that households with larger operational land, less family labor and having higher variety diversification characteristics are more likely to adopt zero tillage practice. The role of irrigation facility was found important for the adoption of green manure practices as farmers were growing green manure crop in spring (dry) season. Similarly, irrigation facility, training and variety diversification characteristics have significant positive influence on the adoption of improve practice whereas chemical fertilizer has negative impact on it.

In addition to realizing economic benefits in seed production phase by gaining efficiency through proper utilizing their resources, seed producers could also realize economic benefits by selling seed in the market. However, to gain efficiency in marketing seed producer organizations need to increase their economy of scale of their outputs. For this, members of their organizations need to supply maximum proportion of the produced seed to their organizations. The study shows that 65% of households sell 64% of the rice seed produced at households in the market. Households' behavior in selling rice seed in the market was analyzed by Heckman Selection model because this model captures the selection bias. The result shows that practice of collecting share by households in seed producers' organizations, livestock holding, and training motivate farmers for selling seed in the market whereas the operational land and irrigation facility motivates them selling higher amount of seed in the market. Seed price positively influence households' behavior in selling rice seed as well as its quantity. Additionally, to see the influence of training on economic efficiency of seed producer organizations in rice seed marketing, return to investment of four organizations from Chitwan district was compared.

The result shows that those spending on training for their members have better return to investment figure than their counter part, and also the efficiency of the former organizations is less sensitive to change in external factors.

In spite of the great potential of seed producers' organization in reducing marketing costs, these organizations possess risks from variability of socio-economic characteristics of their members, and risks from external factors such as market, climate and government policy. Governance issue of these organizations were analyzed from the perspective of the capacity of executive body in designing strategies to address the internal and external factors in line with enhancing efficiency of these organizations in rice seed marketing. These strategies are members' participation, implementation of business plan, development of incentive system, and linkage with service providers. The result shows that organizations are poorer in incentive and business plans as compared to participation and linkage, and organizations from Chitwan district are better off in these indicators as compared to the organizations from other two districts. There is positive impact of governance indicators on technical efficiency and proportion of seed sold by household in the market. It provides the evidence that if seed producer organizations improve their governance indicators, households will realize economic gain. Moreover, leaders' characteristics were compared with the governance indicators across these organizations, and it shows that leaders with higher education level and attended business planning training are better off in governance indicators.

Overall, the study shows that education and irrigation are the most important variables for the better performance of community-based seed production. It means higher educated households could enhance their efficiency by proper allocating their resources, and would be more accountable towards their organizations by participation in the market.

It might be difficult to provide formal education to households considering their age; however, informal trainings and demonstrations about seed production and marketing would be useful for general members. It would be possible to include higher educated members in the leadership position considering existing members' education level. In such situation, development agencies could facilitate the organization in good governance with especial focus on incentive system and business plan. The facilitation might empower the executive committee to select their capable leaders themselves. If the selection of higher educated leaders from existing members is not possible, the seed producer organizations could invite the members having potential leader characteristics in their organizations. Third strategy would be development agencies could support for organizations' leaders for higher education.

The study shows that access to irrigation facility motivates the consumers to buy seed in the market, and contributes in enhancing technical efficiency and motivation of seed producing households in selling seed in the market. Similarly, irrigation facility also motivates farmers in adopting green manure crop, and adoption of this practice is important for improving soil quality. It means extension agencies intended to promote sustainability of rice seed production system should integrate irrigation issue in their program.

Similarly, majority of the rice varieties grown in the study area have not been registered in the government system. So, farmers' might not get extension facility in the non-released/non-registered rice varieties, and it might contribute in inefficiency in seed production and marketing. So, proper mechanism should be developed for the registration/release of these varieties.

Preface

This dissertation aim to contribute on the current debate on sustainability of community-based rice seed production in Nepal using the empirical evidence collected from households and their organizations involved in rice seed production and consumption in the Tarai region of Nepal. Various demographic, economic and institutional variables associated with seed production and marketing were collected from seed producers and consumers from the study area. Governance and seed marketing information were collected from seed producers' organizations. The collected information was analyzed using appropriate econometric tools to address the sustainability question of how seed producers realize economic benefit and how the benefit continues in the future.

This dissertation consists of nine chapters. Chapter one introduces the research problem and its objective. Chapter two discusses the concept of sustainability in the system context, linkage of soil conservation practices and governance indicators with economic benefits to be realized by seed producers. This chapter also summarizes government programs and policies supporting community-based seed production in Nepal. The outcome of this chapter appears as literature review papers in the *Journal of International Development and Cooperation* (2012), volume 18, Number 4, pp. 11-20, and in *Nepal Agricultural Research Journal* (2010), volume 10, pp. 33-40. Chapter three is about the research design, and this chapter gives insight about the conceptual framework used in this study, and methodological approach used in data collection and data analysis. Chapter four analyzes the situation of rice varieties grown by rice seed consumers and their behavior in buying seed from the market. The outcome of this chapter has also been published in the *Journal of International Development and Cooperation* (2012), volume 19, Number 4, pp. 17-27.

From chapter five onwards, the analysis is concentrated on seed producer. Chapter five estimates the technical and allocative efficiency of rice seed producing households, and analyzes the reasons for variation of efficiency level across the households. The outcome of this chapter was shared in *62th annual meeting of Association of Regional Agriculture and Forestry Economics*, Osaka, Japan, and has been published in *Journal of Rural Problem* (2013), volume 49, Number 1, pp. 27-31. Chapter six discusses about the soil conservation practices adopted by rice seed growers in the study area and the roles of households' socio-economic variables in selecting different soil conservation practices. The finding from this chapter was shared in *3rd international conference on conservation agriculture and sustainable upland livelihoods: innovation for, with and by farmers to adapt to local and global changes in Southeast Asia*, Hanoi, Vietnam; and 9th *international conference on environmental, economic, social and cultural sustainability*, Hiroshima, Japan. Also, a paper has been submitted for publication in *International Journal of Sustainability* and it is now in press. Chapter 7 analyzes the impacts of households' socio-economic characteristics in selling rice seed in the market, and outcome of this chapter was presented in the *11th international conference on dry land development: global climate change and its impacts on food and energy security*, Beijing, China. Also, using the finding from this chapter a paper has been submitted for publication in *International Journal of Agriculture and Food Economics,* and it is now under review stage. Similarly, chapter eight analyzes the capacity of seed producers' organizations in governance, focusing on the relation of organizational governance indicators on household level economic indicators. Finally, chapter nine concludes the whole dissertation and gives some recommendations.

Many professionals at various levels contributed in the process of preparing this dissertation. I take this opportunity to acknowledge all of these people who supported me during the course of my Ph D.

I am very much thankful to my major academic supervisor Professor Keshav Lall Maharjan for his guidance during my three years Ph D course giving advice in various stages of my field research, data analysis and manuscript preparation. His encouragement and constructive suggestions have triggered me to make this study at this level, grasping the scientific issues and field reality.

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My sincere gratitude also goes to Mr. Dila Ram Bhandari, Mr. Madan Thapa and Mr. Lal Prasad Acharya from Seed Quality Control Center, the Ministry of Agriculture and Cooperatives, Kathmandu, Nepal for sharing me policies supporting community-based seed production in Nepal. They also provided me opportunity to give my comments and suggestion in the national seed policy document 'seed vision 2021'. Similarly, I am thankful to Agricultural Development Bank, District Agricultural Development Offices, Seed Testing Laboratories and National Agricultural Research Institute for sharing their strategies for supporting community-based seed production system in Nepal. I got enormous supports from rice seed producing farmers and their organizations, and seed consumers in data collection process. Seed producer organizations shared their strategies, innovations, problems, and other documented information. I duly acknowledge these people and their organizations. Similarly, I am thankful to field researchers: Mr. Madhu Gnawali, Mr. Himalaya Subedi, Mr. Achyut Upreti and Mr. Bhuwon Chapagain. It would not have been possible to bring this manuscript in this form without their dedication and honesty in the process of information collection.

I would like to express my sincere thanks to all the students from Maharjan's seminar, IDEC, Hiroshima University, for their critical comments and constructive suggestion in my documents. My remembrance also goes to my brothers Mr. Isowori Prasad Khanal, Mr. Hari Prasad Khanal, Mr. Rishi Aryal, Mr. Krishna Aryal and their family for their inspiration in this study. At last but not least I am very much thankful to my mom (Gunkumari), wife (Prativa) and son (Anshul) as well as all of my other relatives for their inspiration, understanding and supports during my Ph D course.

Narayan Prasad Khanal, Hiroshima University, July 2013

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Acronyms and abbreviations

ADB	Asian Development Bank
AE	Allocative Efficiency
amsl	above mean sea level
APP	Agriculture Perspective Plan
ARC	Agricultural Resource Center
ASC	Agriculture Service Centre
BLM	Binary Logistic Model
CBOs	Community-Based Organizations
CBSPOs	Community-based Seed Producers Organizations
CH_4	Methane
DADOs	District Agriculture Development Offices
DAP	Diamonium Phosphate
DFID	Department for International Development
DISSPRO	District Seed Self-Sufficiency Program
e.g.	Example
et al.	And others
FAO	Food and Agricultural Organizations of the United Nations
FAOSTAT	FAO Statistics
FORWARD	Forum for Rural Welfare and Agricultural Reform for Development
FYM	Farm Yard Manure
GELs	Global Environmental Leadership Program for Designing a Low Carbon World
GHI	Global Hunger Index
GMOs	Genetically Modified Organisms
ha	hectare
HHH	Household Head
HICEC	Hiroshima International Center for Environmental Cooperation
i.e.	That is
IAAS	Institute of Agriculture and Animal Science
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change

K	Potashium
Kg	Kilogram
LFU	Labor Force Unit
Ln	Log
LSU	Livestock Standard Unit
m	Meter
MoAC	Ministry of Agriculture and Cooperative
MoE	Ministry of Environment
MNL	Multinomial logit
MVP	Multivariate Probit
NARC	Nepal Agriculture Research Council
NRRP	National Rice Research Program
n	number of households
N	Nitrogen
N_2O	Nitrous Oxide
NGO	Non-Government Organization
NRs	Nepali Rupees
OLS	Ordinary Least Square
OM	Organic Matter
p	Probability
RTI	Return To Investment
SCP	Soil Conservation Practice
SD	Standard Deviation
SML	Simulated Maximum Likelihood
SRR	Seed Replacement Rate
STATA	Data Analysis and Statistical Software
SRI	System of Rice Intensification
SQCC	Seed Quality Control Center
t	Tones
TU	Tribhuvan University
UN	United Nation
USA	United State of America
US$	United States Dollars
VDC	Village Development Committee
VDI	Variety Diversification Index
VIF	Variance Inflation Factor

Chapter 1. Background of the study

1.1 Introduction

Food insecurity is the global concern (Asian Development Bank - ADB, 2012). Previous conventions related to sustainability /sustainable development such as 'The Earth Summit' held at Rio de Janerio, Brazil in 1992, 'World Summit' / Rio+10 held at Johannesburg South Africa in 2002, and 'Earth Summit' / Rio+20 at Rio de Janerio at Brazil in 2012 recognized that food insecurity /hunger is one of the major challenges for the realization of sustainable development in the world (United Nation – UN, 2012). An assessment of the Food and Agriculture Organization (FAO) shows that people suffering from hunger are increasing in the world, especially in the developing countries (FAO, 2010a). For example, in 2010, 925 million people were suffered from hunger (under nourishment), and this figure is 17% higher than that of 1995. Major reasons for increasing hunger are population growth, economic crisis, speculation in the market, and poor performance of food crops. Among these reasons the last one is more important in the rural areas of the developing countries due to poverty, poor market penetration, subsistence agriculture and climatic factors. It is projected that food production in the world needs to be increased by 70% to feed the global population in 2050 (International Food Policy Research Institute- IFPRI, 2012).

It is projected that food security could continue to be a challenging issue in Asia and Africa in the future. As of 2012, Asia remains the most populous continent, with 4.1 billion people (60% of the world population - 7 billion). The United Nation's estimate shows that from 2012 to 2050 out of the two billions people projected to be increased in the world, Asia will contribute more than half of this increase. Rice contributes 70% of the calorie and 40% of income of Asian people (as 90% the world rice is produced and

consumed in this continent), and it is projected that 50% of the rice production needs to be increased in this content by 2050 as compared to the figure of 2010 to feed the growing population. In addition to this, poverty is a serious issue in this continent. About 22% of the people living in this continent are equal to or below poverty line (per capita income equal to or below US $1.25 a day), and 18% children are under nourished. More importantly, South Asia is worse in these indicators as compared to the other parts of Asia. South Asia contributes 60% of hungry, 65% of extremely poor and 81% of Asian underweight children. The progress assessment of Millennium Development Goal 2012 also reckoned the very high level poverty in South Asia (ADB, 2012). Nepal lies in South Asia and it is considered highly vulnerable to food insecurity. Out of the 119 developing countries surveyed in 2012 with respect to their global hunger index (GHI)[1], Nepal falls in 100th position (GHI: 20.3). This index value is 24.5% less than that of 1990, but it is considered high and Nepal falls under alarming category (IFPRI, 2012). A total of 25% people are below the poverty line, and it is more serious in the rural areas (27% people are poor) (Central Bureau of Statistics – CBS, 2011a).

Rice is the most important cereal crop of Nepal in terms of both food security and livelihood perspectives. Rice contributes 51% of the major food crops' (rice, wheat, maize, millet and barley) production, and this crop supply 40% of the calorie, and 20% of protein supplied in Nepalese diet from cereals. Moreover, rice shares 20% of agriculture gross domestic product and over 70% of the Nepalese people are engaged in agriculture activities including rice (MoAC, 2011). Rice is grown from tarai (from 70m amsl) to mountain (up to 3,050m amsl- the highest rice growing altitude in the world) in Nepal (Paudel, 2011). In 2011, this crop was grown in 1.49 million ha, and the tarai region (up to 610m amsl) shared 69.6% of the total rice area and 72.1% of the total rice

production (MoAC, 2011; FAOSTAT, 2012). In that year, the average rice yield was 2.9t ha^{-1}, and this figure is quite lower than the average rice yield of Japan (5.23t ha^{-1}), China (6.6t ha^{-1}), India (3.5t ha^{-1}), Bangladesh (4.4t ha^{-1}), and world average (4.2t ha^{-1}). Moreover, rice yield growth rate per year remained quite low (2.2%) from 1961 to 2011, this growth rate was only 1% while comparing rice yield data from 2000 to 2011(Figure 1.1). Nepal was the net exporter of food grain including rice before 1980s but after that this country started importing different food grains including rice from foreign countries. For example, Nepal imported 524,592t of rice with the worth of US$ 164.3 million during the period of 10 months (January to October) in 2012 (FAO, 2013). A rice demand/supply scenario projected based on population growth and cereal production data from 1980 to 2010 shows that there could be 19% deficit of rice in the country to fulfill the domestic demand in 2030 (Prasad, Pullabhotla and Kumar, 2011).

Some of the reasons for the poor performance of rice have been reported as limited access of irrigation, fertilizer, improved seed, technical skills, credit and so on (MoAC, 2011).

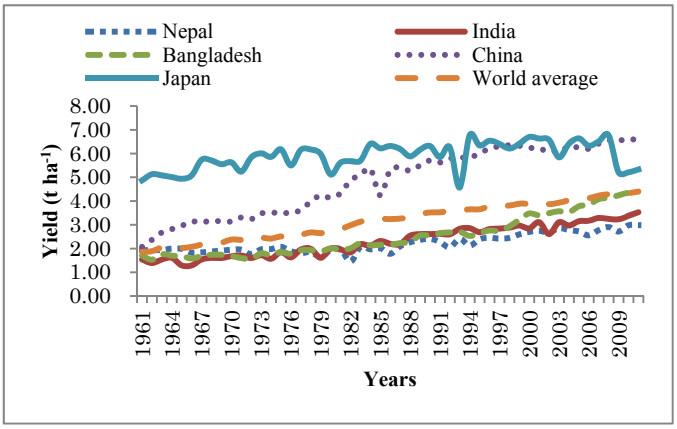

Figure 1.1 Rice yield trend from 1961 to 2011

Source: raw data from FAOSTAT, 2012

Increased farmers' access to quality (genetic and physical purity) seeds of different varieties is considered most important among the aforementioned challenges. It is because quality seed enhances the efficiency of other inputs, and the varietal diversity minimizes risk of crop failure due to diseases, climate, and so on. In Nepal, rice research program was started from 1960, and

by 2010, this country released over 60 rice varieties for cultivation at farmers' level. It is estimated that about 90% of the total rice area is covered by modern rice varieties (Nepal Agriculture Research Council - NARC, 2011). But there is wide gap (50%) between the potential and average rice yield in the country. One of the reasons behind this yield gap is poor access of improved seed (early generation seed of the farmers' preferred varieties) in the rural areas (Upreti, 2008; MoAC, 2011). It is evident from poor seed replacement rate (SRR - the ratio of total seed supplied in the country against the total seed requirement). The government statistics shows that SRR of rice in Nepal in 2010 was 8.7% which is far below the recommendation made for self pollinated crops (25%) (Seed Quality Control Center - SQCC, 2012). Low SRR means that farmers do not frequently change the fresh (early generation) seed, and it is more likely that older generation seed is susceptible to diseases which reduce crop yield.

Out of the total annual seed supply in the country, the share of government-owned company, also known as National Seed Company, is only 17%, and rest of the seed is supplied by farmers' groups and cooperatives, development projects and agrovets (traders dealing with agricultural tools, seed, fertilizers, and so on) (SQCC, 2012). To contribute in the delivery of rice seed in the rural areas research and development agencies started empowering farmers organized in groups/cooperatives for the production and marketing of rice seed from early 1990s (Witcombe, Devkota & Joshi, 2010; Pokhrel, 2012). The subsequent sections in this dissertation deal with the sustainability of the farmers' managed rice seed production.

1.2 Community-based seed production

Community-based seed production (CBSP) is a system of producing and marketing of seed by farmers. This system is synonymously called as farmers' seed production (Almeinders and Louwaars, 1999), informal seed production (Cromwell and Wiggins, 1993), small scale seed production (Lyon and Danquash, 1998) and local seed production (Almekinders, Louwaars and Bruijin., 1994). In this system, farmers' residing in the same geographical area and organized in 'group' or cooperative do seed production and marketing activities (Cochrun, 1994). Seed production is a household level activity and it is the responsibility of households to manage resources in seed production. However, seed marketing (collection, processing, storage and distribution) is handled by their organization (also called as community-based seed producer organizations – CBSPOs). All the seed growers are the owners of CBSPOs and their ownership is reflected by their participation in organizations' decision making process, and sharing costs and benefits of their organizations' activities. The CBSP is also called as intermediary system (Bishaw and van Gastel, 2008) considering its role to make a linkage between formal system (government agencies and private companies) and local system to exchange germplasm and knowledge (Figure 1.2).

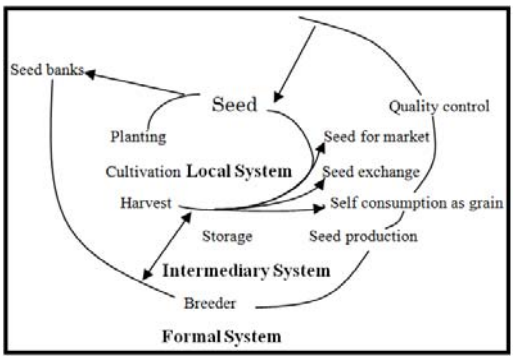

Figure 1.2 Types of seed system
Source: Revised from Almekinders and Louwaars, 1999

The concept of CBSPs came as a response to the failure of the formal system to supply seeds of diversified varieties in a cost effective way in the rural areas. For example, in 1970s, international agencies supported government corporations

(parastatals) in the developing countries to establish organized seed production, processing and marketing facilities. This program could not supply sufficient quantity of seeds of the different crop varieties in the rural areas due to ineffective management, lack of marketing strategies, and high costs involved in the production and marketing. Similarly, the narrow range of crop varieties developed and tested by parastatals using package of practices (e.g. fertilizer, pesticides) could not be applicable to the resource poor farmers. This resulted into the low adoption of these varieties, especially in case of small farmers. Then, in 1980s the international effort was turned towards promoting private seed companies to address the seed delivery issue in the rural areas. Again, this approach could not supply appropriate varieties to resource poor farmers as in the above case. The private companies opened with the objective of supplying cereals seed in the rural areas focused their activities only in hybrid seeds (especially vegetables) due to low profit margin in (non-hybrid) cereal seed (Mywish, Julie and Ducan, 1999; Shrestha and Ednar, 2007).

It is believed that CBSPOs could address the problems faced by the private companies and parastatals, and increase farmers' access to diversified varietal choice. The reasons behind the argument are as follows. First, these organizations could minimize costs in production and marketing because both production and marketing activities are handled at local level with low transportation cost. Similarly, being an intermediary/less formal sector, CBSPOs do not require go through the complex (long seed certification procedure adopted by government agencies) seed certification scheme (David, 2004). Rather, the trained members of CBSPOs monitor the seed production plots, and apply quality assurance technique such as truthful labeling (the technique where the producers declare the quality of their produce themselves). These conditions

help them for cost reduction in the production phase. Third, CBSPs are allowed to produce and sell seeds of the local varieties evolved through farmers' innovations in addition to the modern varieties developed by research organizations. This helps CBSPOs to supply diverse crop varieties in accordance with the local needs that vary across the socio-economic and geo-physical settings (Joshi et al., 1997; Setimela, Monyo and Banziger, 2004).

There is no formal statistics how many CBSPOs are involved in rice seed production and marketing and quantity of rice seed supplied in Nepal. The government statistic shows that 128 CBSPOs (with 2,500 households) registered in the government agencies, out of which 80% are from tarai regions and involved in cereal seed including rice (MoAC, 2009).

1.3 Statements of the problem

Poor seed supply is a serious issue in rice in Nepal though this crop serves as an important source of food and livelihoods of communities. The statistics shows that formal sector (government agencies and private companies) supply < 2% of total annual seed requirement Nepal (SQCC, 2012, Almekinders, Louwaars & Bruijin, 1994; Alemkinders & Louwaars, 1999). Though some CBSPOs are involved in rice seed production and marketing activities with the support from development projects, sustainability of these schemes (whether farmers could continue these activities or not) is a contested issue. The issue has been raised from the perspective of how farmers could be benefitted from seed production and marketing considering their poor resources, poor extension service, no/limited business skills, and promoted these schemes by development projects that are normally more accountable towards donor agencies with less emphasis on local empowerment (Cromwell & Wiggins 1993;

Mywish, Julie & Ducan, 1999; Bishaw & van Gastel, 2008). As a result, policy makers and donor agencies are also in the confusion about the supporting areas they have to focus on to strengthen the capacity of community-based seed production.

In spite of this problem, very limited studies have been published in this system. Also, the available studies are focused mainly on review of government policy documents focusing on seed regulatory framework and subsidy issues (Cromwell & Wiggins 1993; Almekinders and Louwaars, 1999; Mywish, Julie & Ducan, 1999; Bishaw & van Gastel, 2008), and very limited efforts have been made to understand the sustainability issue using empirical evidence (i.e. using data collected from field). These studies assumed sustainability of CBSP from the perspective of whether CBSPOs cover their management costs involved in seed marketing or not (Poudel et al., 2003; Joshi, 2006; Lal, Thapa & Grunat, 2009; Witcombe, Devkota & Joshi, 2010). Also, data used to analyze the capacity of CBSPOs in covering marketing costs or not were estimated seed production data, and not the actual volume of seed sold. Studies carried out using such estimated data could not represent the ground reality because they failed to capture household level issue. Understanding household level concerns is important to design appropriate incentive mechanism for farmers, especially in the countries where national rice seed industry is in the early phase of development (Morris, Smale & Rusuke, 1998; Almekinders & Louwaars, 1999).There are very limited published studies about the sustainability of CBSPs using household data (David, 2004; Srinivas et al., 2010), and also the major focus of these studies is limited on economic issue. It means these studies have not considered social and environmental concerns in the sustainability. However, these two issues along with economic issue are important in the sustainability analysis (World Council on Environment and Development- WCED, 1987).

1.4 Study rationale

It is clear from the existing literature that food security is a key issue in Nepal, and the situation has been worsen in recent days due to various factors such as population growth, speculation in the market and poor performance of food crops (MoAC, 2011). More importantly climate change, especially uncertainty in rainfall patterns, has made the food security situation worsen due to its negative impacts on crop yield. Resource poor farmers who depend on rice farming for their livelihoods are the most suffers from this phenomenon. To address the abovementioned challenges in a sustainable way, increased farmers' access to diversified rice variety choice including local varieties is important. Researchers and policy makers are struggling to identify appropriate mechanism to increase farmers' access to diversified variety choice as multinational companies and government corporations have been already failed to address this issue, and narrow range of rice varieties supplied by these organization could not address small farmers' concerns.

In Nepal, rice farming is a traditional practice carried out by farmers. It means farmers have lots of experience and local knowledge about rice farming and its on-farm seed management technique (Gamba *et al*., 1999; Bishaw, 2004; Bania *et al*., 2000; Joshi, 1997). This country is also rich in rice biodiversity due to variation geographical niches (Rana et al., 2007). It is increasingly recognized the importance of local landraces to enhance livelihoods of people in a sustainable way. Farmers in these areas could not offer hybrid rice varieties which demand intensive management including the use of chemical fertilizers and pesticides. Even the farmers from developed countries who have been using hybrid rice varieties for a long time have started emphasizing local rice varieties and their seed production to enhance sustainable rice farming system.

At the circumstance of biodiversity loss from the formal seed supply system, community-based seed production system could serve as an alternative seed delivery technique. This system conserves the local biodiversity and indigenous knowledge gained by farmers for a long time.

The selection, saving and exchange of seed is an integral part of rice production system being adopted by farmers traditionally in the world. Empirical evidence shows that farmers possess a wealth of indigenous knowledge and experience concerning on-farm seed management (Gamba *et al*., 1999; Bishaw, 2004; Bania *et al*., 2000; Joshi, 1997). It means farmers could manage seed production and marketing activity at local knowledge provided that they get some knowledge about seed quality and marketing concept. More importantly, being a self-pollinated crop, it is not difficult to adopt seed quality management measures such as roughing, isolation distance in open-pollinated rice varieties as compared to cross pollinated crop varieties.

Considering the importance of community-based seed production system, policy makers associated with the food security, seed security, and climate change adaptation and have emphasized in local level seed management initiatives. Similarly, the necessity for strengthening CBSPs/local seed system is highlighted in national and international levels to enhance resilience of farmers against external shocks such as climate change. For example, this concept is mentioned in 4th assessment report of inter governmental panel on climate change (IPCC, 2007), and National Adaptation Program of Action Nepal (MoE, 2010).

As discussed already CBSP system has been promoting by development projects. These projects support farmers for inputs and capacity building activities through trainings, excursion visits, and so on. Realization of benefits by households in rice seed

farming would motivate farmers to increase their involvement in rice seed production or continuously engages in rice seed production. So, increased understanding on roles of households' attributes on realizing benefits would be useful in understanding sustainability of farmers' managed seed production system. Better understanding in this area would contribute in strengthening the community-based seed production system by allowing policy makers in designing appropriate policies for their promotion in national level.

1.5 Objective of the study

General objective

The general objective of this research is to assess the roles of household characteristics in economic, environmental and social performance of seed producers. Here, economic performance indicates efficiency of seed production and marketing, environmental performance shows the behavior of these households in adopting soil conservation practices. Similarly, social performance means ability of seed producers' organization in designing policy to address democracy and risk situations.

Specific objectives

1. To analyze adoption of improved rice varieties in the study area
2. To determine the efficiency of farmers in rice seed production and identify factors influencing it
3. To assess the soil conservation practices adopted by seed growers
4. To analyze the rice seed marketing in the study area
5. To analyze the capacity of farmers' organizations in governance

Chapter 2. Literature review

2.1 Introduction

This chapter presents the information gathered from existing literature regarding the concept of sustainability and it meaning while using in system context. It also discusses the factors associated with the success of community-based seed production concept. It also summarizes roles of soil conservation practices for the sustainability of rice production. Summary of programs and policies adopted by government agencies and NGOs have also been incorporated in this chapter. The findings from this chapter are utilized in developing conceptual framework in Chapter 3.

2.2 Concept of sustainability

The term 'sustainability' is derived from the Latin word Sustinere, meaning to sustain, endure or support or continue (Onions, 1964). Though the idea of maintaining or sustaining the benefits of any initiative is not new, the word 'sustainability' started appearing frequently in the literature from 1970s to address the preservation of ecology for maintaining ecosystem services. Later, 'ecology' was merged with 'development' in the form of 'sustainable development' when Brundtland commission defined sustainability in the form of sustainable development considering the role of economy and society. According to the Brundtland report "Sustainable development is the development which meets the need of present without compromising the future generation to meet their needs" (WCED, 1987:43). This definition addresses the intra-generational and intergenerational equity. The intra-generation issue highlights necessity to address the issues of poor people in the current generation whereas inter-generational equity focuses for maintaining the regenerative capacity of ecological system under different shocks situations, and enhancing the innovation capacity of

social system. The term ‘development’ is a dynamic concept, and it implies that the socio-ecological system needs to address human needs in the changing contexts.

As mentioned in the above definition one of the essential human needs for the present and the future generation is food and it is the product of agriculture. At the same time agriculture has wide spread environmental impacts through the emission of green house gases such as methane (CH_4), Nitrous Oxide (N_2O) and so on. It is well recognized that sustainable agriculture deals with the objective of sustainable development by enhancing the food production and by minimizing the environmental impacts of agriculture.

The definitions of sustainable agriculture can be broadly divided into two parts: ‘goal describing’ and ‘system describing’, and these concepts give two schools of thoughts. The goal describing concept deals sustainability in agriculture from the perspective of promoting practices in agriculture that are alternative to conventional practices that use more chemical fertilizers and pesticides. This concept came from the developed countries such as United States of America, Canada and Western Europe considering how the impact of agriculture on non-renewable resources (e.g. fossil fuel), soil degradation, water resource, health and environment could be reduced. Studies dealing with the farmers in these countries considered unsustainable agriculture for the conventional agriculture, and there was no concern of how to increase food production as they have already reached at high productivity level. In contrary to this, studies concerning with agriculture in developing countries argued that the goal describing concept might not be applicable in the rural areas of these countries. It is because majority of farmers in these countries are small holders who employ subsistence farming utilizing negligible amount of external inputs. Crop productivity level is quite

lower than that of developed countries though poverty and food insecurity is pervasive. So, the major concern of these farmers is how to increase the current production level and how to maintain the new productivity level using the local resources. So, the system describing concept is better suited to deal with the sustainability of agricultural initiatives in these countries.

The system describing concept interprets sustainability as the ability of the system to produce output that is well valued by actors and sufficient input is supplied and continuity of output for long time (Lewandowski et al, 1999). There are several definitions of sustainable agriculture under the system describing concept, and the broad consistency among the definitions is that 'sustainable agriculture is the use of resources to produce food and fiber in such a way that the natural resource base (such as biodiversity, soil quality, forest, water and air quality) is not damaged, and that the needs of producers and consumers can be met over the long term (Schaller, 1993).

In agricultural sector, producers and consumers are the major actors. Producers intend to maximize the benefit from agricultural production whereas consumers' interest is to access quality product in cheap price. It is difficult to demarcate whose benefits to be measured in the production and consumption chain of agriculture outputs. From the shareholders' perspective, benefits of seed producers might be more important but if we look at the same issue from stakeholders' perspective issues of rice grain consumers (which might not be necessarily the farmers) need to be addressed. However, diversity of rice varieties in cheap price could address this issue.

Similarly, how long the current level agricultural benefit continues is complex in the changing context. It is complex to precisely estimate benefit in the changing contexts. The logical way to address this problem is to how agricultural activities could minimize

their impact on natural resources and how to enhance the innovation capacity of people so that they could averse the risk situation or maintains the regenerative capacity of socio-ecological system in a short period. Sustainability can also be discussed at the organizational level. Organizations are role oriented institutions and they are formed according to government policy, and in this sense they are sustainable (Huntington, 1968). However, structures and activities of organizations might be changing in accordance with the needs of their stakeholders. However, researchers dealing with sustainability of agricultural organizations concern on whether these organizations could cover their full/partial operating costs or whether they could address the equity issue (i.e. the concerns of poverty) or not, whether they have developed strategies to address the risk situations or not and so on (Mac et al., 1989). The sustainable performance of people /organizations is measured considering three indicators: economic, social and environmental.

2.3 Life cycle of seed industry development

Morris, Smale & Rusuke (1998) summarized the evolutionary growth path of maize seed industry as their 'life cycle' into four stages: pre-industrial, emergence, expansion and consolidation. Each stage of the life cycle is characterized by a particular combination of factors relating to the orientation of agriculture, farmers' seed acquisition practice, availability of technology, locus of research and development, predominant seed production method and intellectual property right (Table 2.1). Cereal seed industries in developing countries are in either pre-industrial or emergence stage, where development agencies and non-government organizations (NGOs) provide seed and other extension facilities such as trainings. The extension facilities might be in the form of subsidy in source seed, credit, processing machines and trainings. On the other

side, extension agencies could also facilitate seed consumers to buy seeds of new varieties produced by CBSPOs by providing subsidy on seed or by organizing demonstration plots of the varieties. The intension of the extension agencies is to create conducive environment for seed producers that contribute to enhance their efficiency in seed production, and to motivate consumers to increase the frequency of seed replacement.

Table 2.1 Factors associated with the different level of seed industry development

Factors	**Pre-industrial**	**Emergence**	**Expansion**	**Consolidation**
Orientation of agriculture	Subsistence	Semi-subsistence	Mostly commercial	Completely commercial
Seed technology	Local varieties (LV)	LV and some hybrid	Mostly hybrid	Only hybrids
Seed procurement	Local exchange	Some purchasing	Frequently purchasing	Annually purchasing
Seed production	On-farm	Public organization	National private company	Global private company
Market coverage	Local	Local &regional	National	International
Agriculture information	Own-experience	Public extension	Private company	Private company
Locus of seed research	On-farm	Public organization	Public and private organizations	Specialized public and private organizations
Legal framework	Customary law	Civil	Commercial (domestic)	Commercial (global)
Property right	None	None	Trade secret	Variety patent

Source: Morris, Smale and Rusuke, 1998

The efficiency gain by producer would contribute towards paradigm shift of seed industry into other stages. Looking at the example from maize seed industries of United States of America though maize seed industries were set up in 1930s, the seed industries made significant progress after 1970 due to the implementation of patent right concept.

This encouraged the private agencies to invest on research and development of new hybrid varieties using biotechnological and field experiments. It not necessary that seed industry in each country and will follow the same path. It means being a cross pollinated crop farmers intend to replace to seed stock faster but the case in self-pollinated crop species might be different. However, researchers argued that the major driver of the change from one stage to another is efficiency gain by producers and consumers. It means the seed producers gaining higher efficiency are more likely to change from one phase to another. Therefore, government agencies and NGOs provide trainings to enhance their capacity, and arrange for the provision of resources that are needed for seed production and marketing.

2.4 System approach in sustainable development/sustainability

It is clear from the literature that the quest for sustainability and sustainable development requires integrating economic, social and environmental factors. This concept also highlights necessity to integrate spatial and temporal dimensions of sustainability in the form of intra-generational as well as inter-generational equity. System approach is considered to grasp these perspectives because the system view is a way of thinking in terms of connectedness, relationships and contexts. This approach is contextualized in the particular socio-ecological system, where societal (human) and ecological sub-systems interact with each other or function themselves. The discourse here is whether to look at sustainability of human sub-system or ecological sub-system or socio-ecological system as a whole. Classical economists view earth as an artificial planet considering complete substitution between human capital and natural capital. The sustainability of ecological sub-system is viewed as important only as far as required for the sustainability of the human component, and considering the little knowledge about

the future uncertainty precautionary principles were applied in order to incorporate appropriate level of risk aversion in the face of uncertainty.

The sustainability of ecological system views that natural resources cannot be substituted with human-made capital. This notion is also in line with very strong sustainability and considers steady state economy without considering poverty or people. The notion of socio-ecological concept is more important considering the inter linkage between society and ecological sub-system. This system provides the basis for the availability of resources such as assets and entitlements, adaptability, flexibility and innovation capacity. It means sustainability is not equal to constancy. Sometime sustainability is perceived as a fixed state of a system but it is not scientifically correct because even ecological system is in changing over time, involving renewal and destruction of component adapting to change in their environment and coevolving in it. So, the concept of sustainability is viewed from sustainable development because the term development stands for change though it may be quantitative of qualitative. Here what is sustained or has to be made sustainable is the process of improvement of human condition (or better off of the living condition where human being resides), a process that does necessarily require indefinite growth in the consumption of energy and material. Also we are living through the period of tremendous demographic, technological and economic transformation and in this process change is unavoidable. Now the question is what is to be changed such as rigidity and impediments, saving knowledge, experience and innovation. So, sustainable should address inter and intergenerational justice, dynamism as technological innovation and change in a social organization makes the system dynamic.

While linking the system concept in seed production, the definition proposed by Brinkerhoff and Goldsmith (1990) in defining rural institution might be appropriate. They argued that sustainability of rural agricultural institutions should be analyzed putting producers and consumers in the context. Producers intend to maximize the benefit from their production whereas consumers' interest is to access quality produce in cheap price. It means producer will continue producing food if the output they produce will be valuable to them and to the consumers. How long the value of their output will remain same is difficult to estimate. This inter-generational issue can be addressed only by assessing how seed producers adopt soil conservation practices which have potential to maintain soil, water and air quality (Gupta & Sayer, 2007).

2.5 Factors affecting performance of CBSPs

The available literature suggests that cereal seed industry in the developing countries is in pre-industrial stage or emergence stage (Morris, Smale & Rusuke, 1998). In these stages, agriculture is mainly subsistence in nature and very few farmers adopt modern varieties. Development projects implement awareness raising projects to motivate farmers for the production and consumption of seed. Some of farmers might start seed production activity in the form of group or cooperative but due to differences in their socio-economic status, all might not be ready for selling seed in the market. So, it is important to analyze the performance of seed producers into production phase and marketing phase. Potential factors affecting the performance of CBSPs are divided into external factors and internal factors.

2.5.1 External factors

External factors are those which are out of the control from seed producers**.** These factors include the policy and programs of the government as well as NGOs because

these agencies are the major service providers for seed growers and their organizations. Seed consumers also called as demand actors could also influence the behavior of seed producers. So, how policy environment and consumers influence the performance of seed producers is discussed here.

2.5.1.1 Policy environment

Government agencies and NGOs are the major service providers for CBSP in the early phase of development. So, rules, regulations and strategies adopted by these organization while delivering extension services. The issues associated with government agencies are provision for source seed, seed testing facility and trainings about technical and managerial aspects of seed production and marketing.

Government owned research farms develop rice varieties and provide source seed to farmers for seed production. The associated issue is whether the varieties developed by government research organizations could address the demand of different categories of farmers. Almekinders, Louwaars & Bruijin, (1994) reported that in many developing countries still the variety development task is limited on government agencies. The varieties developed by these organizations are evaluated considering the resource rich farmers using package of practices (combination of recommended inputs), which could not be practicable to the small / resource poor farmers. In recent years, participatory plant breeding approach (the method of developing varieties in partnership with farmers using inputs used by farmers) is recommended to address this issue (Witcombe & Virk, 1997; Joshi et al., 1997; Joshi et al., 2012). In this approach, farmers learn about plant breeding techniques including strategies to be adopted for the maintenance of genetic purity. But, participatory plant breeding is still limited in the activities of NGOs, and it is yet to be institutionalized in government policy in many countries. For example, seed

policy in Vietnam, does not allow for registration of farmers' bred varieties (Witcombe & Virk, 1997). Unless the approach is clearly mentioned in the government policy it is less likely that projects/programs implemented by government agencies adopt the approach. In Nepal, participatory plant breeding has been institutionalized in the government policy which is seen from the release of rice varieties developed from this approach (Joshi et al., 2012).

The second policy concern is provision of skills (technical and business). The provision of these skills is based on how the provision of these services is integrated into the government policies. Almekinders, Louwaars & Bruijin (1994) argued that normally development projects are designed in line with government policies are less worried about the capacity building of seed producers but are more focused on how they could achieve their development goals by mobilizing the seed producers. It is because the major objective of these agencies is to cover the large number of beneficiaries/farmers by distributing improved seed, and strengthening the capacity of seed producers would not be their priority. However, development projects mobilize CBSPOs in distributing seed in local areas and/or in multiplying seed as per the demand of development projects as CBSPOs could accomplish these activities cheaply. David (2004) argued that there should be a provision of supporting extension service to CBSPOs by government agencies even if these organizations are empowered by NGOs. However, the nature of supports might vary with the stage of seed industry development in the concerned countries. The possible supporting areas are training on business plan development and its implementation for the production and marketing of seed, subsidy for the development of physical structures (such as grading machine, seed storage building), provision of credit facility on low interest rate, and contribute in creating

demand of seed produced by CBSPOs through demonstrations /networking (Witcombe, Devkota & Joshi, 2010).

2.5.1.2 Seed demand characteristics

In rural areas, there is heterogeneity of farmers in terms of their socio-economic characteristics such as land size. Normally, larger farmers tend to adopt modern varieties/hybrid varieties in combination with other agricultural inputs such as chemical fertilizers/pesticides and so on. On the other hand, small farmers' priority might be to grow crop varieties that need less external inputs and are more risk averse in nature. Similarly, the price of seed, characteristics of the varieties, cropping pattern, land characteristics, etc, affect the behaviors of farmers buying seed from the market (Nkonya & Norman, 1997; Paudel & Matsuoka, 2008)

2.5.2 Internal factors

2.5.2.1 Socio-economic characteristics of seed growers

Previous studies have shown that demographic (age and education of household, family size), economic (operational land, irrigation facility, fertilizer, soil or land characteristics, etc), and institutional (membership in the organization, access to training, etc) variables are associated with their efficiency in utilizing resources and participation of farmers in the market (Rana et al., 2007; Idiong, 2007; Piya, Kiminami & Yagi, 2012).

2.5.2.2 Organizational management

In general, in CBSPs, seed production is carried out at household level but marketing through their CBSPOs. The marketing activities of CBSPOs include collecting raw seed from individual growers, process it, store it and distribute to consumers. They also provide technical services to their members through training or

monitoring visit (Kubei, 2007; Witcombe, Devkota & Joshi, 2010). To handle all these activities CBSPOs form executive committee from the members following democratic principles, and this committee takes the overall responsibility to make necessary decisions in the organization respecting their members' views. CBSPOs in developing countries are in the form of groups or cooperatives, and many cases these structures are the continuity or some modification of the traditional social organizations whose objectives would be primarily of overall socio-economic development of members. The challenge for these cooperatives would be the issue of free riders, horizon, control and influence cost (Acharya, 2009) for their sustainability. The issue of common property (free riders) problem might arise when property rights are not sufficiently defined to ensure that individual bear the full cost of action or receive benefits from their actions. The horizon problem arises when cooperative address only short-term benefit at the expense of long-term viability of the cooperative. For example, one one-member one vote principle might not motivate the members to invest in the organizations, and as a result organizations could face shortage of financial resources. To address these problems, CBSPOs form executive body from members who lead the organization, initiative activities, create policies and problems, defend the policies and programs with their members, and coordinate with service providers such as government agencies (Chand & Karki, 2005).

Another challenge of executive committee is how to develop policies that are suitable for heterogeneity of their members. It is because many of the cooperative organizations in the developing countries been promoted from the perspective of poverty reduction rather than their interest or potential or challenges while starting seed production and marketing activities (Acharya, 2009). It means poorer members might

face difficulty if organizations demand large amount of money to start up their business activities, and sometimes members might leave the organizations not being able to pay for the fee set by their organizations. This implies that 'executive committee' needs to address the interest of all categories of their members to enhance their loyalty and accountability towards their organizations.

Similarly, executive committee might face the conflict on 'conformance role' vs 'performance role'. The conformance role requires that the executive committee need to work for the welfare of their members, especially for poor people, whereas performance role requires them to demonstrate the performance of their organizations (for example organizations' physical structure development, efficiency in marketing, etc). Generally, better off members Also, the executive committee might face challenges from government side what benefit they have created to the local community. It is because the expectation of consumers towards seed producers is to get quality seed in cheap/reasonable price. So, the organization could handle these issues by enhancing economic efficiency in marketing, and designing policies for good governance in the organization. The good governance in CBSPOs could be understood by analyzing the capacity of executive's members in designing and implementing policies for participation, planning, business plan development and linkage with service providers (Gray & Kraenzle. 1998; David, 2004; FAO, 2010b). Previous studies have shown that education, training, previous business experience of leaders, and physical structure of organizations would have significant positive impacts on organizational performance (Setimela, Monyo & Banziger, 2004; Bishaw & van Gastel, 2008). Kugbei (2007) argued that it might be difficult for CBSPOs to implement its activities timely unless they prepare business plan as it guides them what activities to be implemented when by

whom. Similarly, the case of Nigeria shows lack of business plan was the major reason behind the low performance of CBSPs (FAO, 2010b).

2.6 Soil conservation practices for sustainability of rice-based system in Nepal

Declining water table, poor soil organic matter and emission of Greenhouses Gases (GHGs) are the major environmental issues associated with the sustainability of rice-based system in indogangetic plain including Nepal. This system emits nitrous oxide (N_2O), Carbondioxide (CO_2) and Methane (CH_4). Existing literature suggests that though Nepal's share to global GHG emission is negligible (0.025%) the emission rate is very high (IPCC, 2007). From 1990/91 to 1994/95 Nepal's GHG emission increased by 13.1% per annum and agriculture and forestry sectors were the major contributors of the emission (Maharjan, Joshi & Piya, 2011). The emission of N_2O is mainly concerned with the application of nitrogenous chemical fertilizer whereas CO_2 with fossils fuel consumption and CH_4 with water logging condition in rice, manure management, and burning of crop residues. Soil conservation practices (SCPs) have been proposed to address these problems in an integrated manner. These practices are built on integrating local resources and indigenous knowledge farmers have gained from long period of time (Dumanski et al., 2006; Tripathi et al., 2006; Regmi et al., 2009). This section discus how SCPs address the aforementioned problems, taking the cases of soil organic matter enhancing practices, and energy saving practices.

2.6.1 Soil Organic matter management practices

Organic matter enhancement practices in rice-based system of Nepal include farm yard manure (FYM), compost, green manure, botanical pesticides and so on (Tripathi et al., 2006; Regmi et al., 2009). It is clear from the previous studies that organic matter (OM) is the major source of soil carbon and other plant nutrients in the soil and it results

to improve the soil quality and crop yield (Stanhill, 1990). For example, incorporating mungbean biomass, a source of organic matter, after two pickings of pods in rice fields increases the grain yield of rice by 20% (Khanal et al., 2006). Similarly, incorporating asuro(*Adhatoda* sps) leaf increases the rice yield by 45% (Subedi, 1992). Moreover, in-situ incorporation of dhaincha (*Sesbania* sps) increases the rice yield by 25%. Green biomass of these species is rich in plant nutrients, especially in nitrogen (1.8-2.5%) which results into increased crop yield. Similarly, green biomass incorporated fields have higher microbial biodiversity which is important for maintaining soil health (Devkota et al., 2006).

Various physiochemical and biological basis have been postulated to describe the mechanism behind the roles of organic matter in the sustainability of rice-based system. The first mechanism is associated with tolerance to drought. Organic matter holds moisture and makes it available to plant roots, so under drought condition, crop yield in organically managed systems is higher than that of crops managed integrating chemical fertilizer and organic manure (Dormaar, Lindwall & Kozub, 1988; Denison, 1996). The second mechanism is to facilitate plant roots to uptake nutrients from soil. The population of mycorrhizae (a symbiotic association of fungi with plant roots) has been shown to be more abundant in the roots of crops grown in soils with higher organic matter (Eason, Scullion & Scott, 1999). This makes the plants able to extract nutrients that are bound with soil particles and not easily available to plant roots. Thirdly, organic matter leads to improve soil stability and resistance to water erosion due to higher carbon content and improved soil aggregation. Better soil aggregates improve permeability, lower bulk density and enhance resistance to wind and water erosion (Stanhill, 1990).

In addition to the aforementioned economic benefits organic matter contributes in minimizing the emission of GHGs. For example, organic soil has higher potential of carbon sequestration than inorganic soil due to the formation of microspores in the organic soil. Moreover, organic matter management technique contributes in reducing the emission of methane. Rice field is the importance source of methane emission in Nepal. In 1994/95, rice fields emitted 306 giga tons of CH_4 which is equivalent to 35% of the total CH_4 emitted in the country. Anaerobic decomposition of organic matter in the flooded field produces methane and is escape to the atmosphere by diffusion process. The major pathways of CH_4 production in flooded soils are the reduction of CO_2 with H_2, with fatty acids or alcohols as hydrogen donor, and the transmethylation of acetic acid or methanol by methane-producing bacteria (Dormar, Lindwall & Kozub, 1988). Incorporation of poorly decomposed OM in soil increases the emission of CH_4. The FYM/compost, which is the most dominant source of OM in Nepalese rice-wheat system, is prepared through anaerobic fermentation and even the fermented product is not well-decomposed in most of the cases (Subedi, 1997).

In addition to emitting CH_4, the poorly decomposed manure also increases severity of crop pests. This can be solved by the use of effective microorganisms such as *Trichoderma* spp., *Gliocladium virens* as they accelerate the manure decomposition process. Also, increased aeration in manure pit has been found effective to minimize the emission of CH_4. Another option to minimize emission from manure is the promotion of bio-gas plants. While doing so, CH_4 produced from decomposed organic matter can be utilized as a source of household energy and the slurry (by product from biogas plant) can be used as organic manure in crop fields. A study has shown that biogas could

reduce emissions by approximately 60% as compared to FYM prepared from conventional method (Eason, Scullion & Scott, 1999). So, biogas saves fossils fuel by providing alternative energy source for household energy consumption, and at the same time it mitigates GHGs from animal manure. There is a growing trend of establishing biogas plants in the country and clean development mechanism of the Kyoto Protocol seems to be a good opportunity to promote more biogas plants in the country (Maharjan, Joshi & Piya, 2011).

The emission of N_2O from rice-based system is linked with the nitrogen cycle associated with the system. Farmers use both chemical fertilizers (e.g. urea) and organic sources (FYM/compost, green manure) in rice field. Also, nitrogen is added in the soil by symbiotic (if green legumes grown in the field) and non-symbiotic (e.g. blue green algae) nitrogen fixation processes. When nitrogenous fertilizers dissolve/decompose in soil, ammonium (NH_4^+) ion is released and it further converts into nitrate (NO_3^-) ion through the process called nitrification. This nitrate ion is taken by plant roots. But the plant roots do not uptake all the nitrate ion at the same time, the remaining part is lost either through leaching or through denitrification (the process through which the nitrate form of nitrogen converts into nitrous oxide or nitrogen gas). Studies have shown that 30-70% of nitrogen applied through chemical fertilizer in rice field in Nepal is lost through denitrification and leaching (Toomsan et al., 2000; Pandey, Shah & Becker, 2008).

In case of rice-based system, during the wheat growing season (November to February), most of the nitrogen applied in the soil is taken by wheat crop and therefore the loss of N_2O and NO_3^- is generally low. After harvesting wheat crop, temperature of bare soil increases due to intense sun light. Then, the process of mineralization and

nitrification is accelerated by which the nitrogen bound in the plant roots and organic matter (in ammonium form) is released (in nitrate form). Pande, Shah & Becker (2008) found that NH_4-N content in the bare soil decreased from 21.2 to 5.9kg ha^{-1} and from 12.3 to 9.3kg ha^{-1} after six weeks of wheat harvesting in the year 2001 and 2003, respectively. But they found N_2O peak (11micro mol m^{-2}) to have reduced drastically (2 micro mol N_2O m^{-2}) after the rain. This is due to the fact that when N_2O reacts with water it converts into No_3^- form and leaches out from the soil surface. Similar studies carried out in China and India have found that N_2O is lost from the bare soil in the range of 0.034–0.06kg N_2O–N ha^{-1} during the spring season (Chen et al., 1997). There is no exact information available how much amount of N_2O is emitted from rice-wheat system as a whole from per unit land in Nepal.

There is about 0.4 million hectare land fallow in the spring season due to limited irrigation facility, agronomic options as well as free grazing (Khanal et al., 2006). At this circumstance, planting spring season crops at the fallow land holds enormous potential to mitigate N_2O emission from soil. Field experiments carried out in Chitwan and Rupandehi districts of Nepal from 2001 to 2003 show that growing maize, mungbean or macuna reduces the NO_3^- nitrogen peak by 50 to 75%. However, macuna shows the highest response (75% reduction) and is followed by mungbean (65%) and maize (20%) with reference to loss of nitrate nitrogen from bare soil 20kg ha^{-1}) after 7 weeks of wheat harvesting. The plant analysis showed that total N accumulation by mucuna, mungbean and maize was 108, 80 and 54kg ha^{-1}, respectively. These results demonstrate the high potential of spring season crops in trapping the nitrate nitrogen from atmosphere. However, the legumes are considered much more important than maize considering their roles in fixing atmospheric nitrogen.

2.6.2 Energy saving practices

Zero-tillage (ZT) is a method of tilling the field with minimum soil disturbance. It is synonymously used with conservation tillage because minimizing the soil disturbance improves soil quality and production efficiency. Based on crop species in which it is applied ZT is named with some modification. For example, if small band or trench is made while applying the ZT practice in legumes to ensure the crop establishment covering the seed with the layer of soil or organic matter, it is called strip-tillage or minimum tillage or reduced tillage (Dumanski et al., 2006; Derpsch, 2007). And if seed is sown directly in the field manually or using seed drill, it is called no-till or surface seeding, and this practice is common in wheat in India and Pakistan, and is spreading to Nepal (Tripathi et al., 2006). In this article ZT is synonymously used with surface seeding or no-till.

ZT is a traditional practice in Nepal being adopted by farmers in lentil, wheat, garlic and linseed since the long time period, especially in the residual moisture that exists after rice harvest. However, in all the above cases seed sowing is done manually. National wheat research organization started on-station research on surface seeding in wheat in the 1980s, and from the 1990s, the organization started validating the practice in farmers' fields. From mid 1990s research activities were started for the validation of seed drills for surface seeding in wheat both in on-station and on-farm conditions (Tripathi et al., 2006; Regmi et al., 2009).

Though there is no common practice of ZT in rice, its application even in wheat offers various socio-economic benefits to rice growers. The first one is associated to increasing cropping intensity and yield. Studies have shown that it is possible to sow wheat about 15-20 days earlier than that of the conventional practice through ZT (Ladha

et al., 2003; Regmi et al., 2009). As a result, wheat can be harvested earlier and it is possible to grow spring season crops such as maize, mungbean and so on. Timely planting of wheat (Oct 15 to Nov 15 as per recommended by NARC) is also important to escape the problem of terminal drought that causes sterility problem in wheat. Studies have shown that planting of wheat after first week of December reduces its yield @ 1-1.5% per day (Gupta & Sayre, 2007; Ladha et al., 2003). Regmi et al. (2009) found 30-40% higher yield in ZT practice as compared to conventional practice in tarai areas of Nepal. Similarly, Shah et al. (2011) found 16% higher wheat grain yield in ZT (1.8 tha^{-1}) than that of conventional tillage (1.58t ha^{-1}) in case of Rampur district. The long-term experiments carried out in India and Pakistan from 1985 to 2003 show 30-50% higher grain yield of wheat in ZT as compared to the conventional one (Erestein, 2009). It is estimated that about one-third of wheat in Nepal is planted late due to late-maturing rice varieties such as Basmati and Radha 12. At this circumstance, ZT would positively contribute to solve this problem by allowing farmers to sow wheat on time.

Second benefit from ZT is related to increasing energy use efficiency. In Nepal, about 30-40% of the total production cost in wheat is involved in land preparation (Yadav et al., 2010). Erenstein & Farooq (2009) showed that ZT saves cost (US$ 52 ha^{-1}) due primarily to the reduction in tractor time and fuel for land preparation, which leads to into higher benefits of US$ 97 per hectare than conventional practice. Similarly, Regmi et al. (2009) claimed that ZT saves 64% of the total cost involved in land preparation.

ZT has been found promising not only in land preparation but it makes the others intercultural operations easier. For example, it is easier to control obnoxious weeds like

Phalaris minor in ZT if wheat is sown using seed drill. Since this machine sows the seed in rows and it makes the weeding easier (Erenstein & Laxmi, 2008). ZT also increases the water use efficiency allowing the field to irrigate faster as compared to conventional tillage. It is due to the fact that more water is needed to irrigate tilled soil than non-tilled soil. Studies (Ladha et al., 2003; Gupta & Sayre, 2007) have shown that ZT saves 30-50% water in wheat considering two irrigations (first during crown root initiation stage after 25-30 days of seed sowing and second during flowering). In addition to wheat, ZT technique was also tested in rice through direct sowing of rice seed, but the crop yield was found lower (5.5t ha^{-1}) than that of conventional tillage (6.3t ha^{-1}). Heavy infestation of weed is one of the factors reducing rice grain yield (Regmi et al., 2009).

In addition to economic benefits, ZT contributes to social benefits. One of such benefits is associated with the time saving. There are evidences that households can use time saved while adopting ZT in social, and leisure purposes (Erenstein & Farooq, 2009). Women generally appreciate ZT due to less anxiety at the time of wheat field preparation, and this results into more peace at home (Erenstein & Laxmi, 2008; Gupta & Sayre, 2007). Similarly, Joshi, Mudwari & Bhatta (2006) claim that ZT contributes in enhancing nutritional security of women by allowing them additional time to grow other food sources such as vegetables.

The environmental benefits of ZT are associated with its potential to minimize the consumption of fossil fuels needed for tillage operations and irrigation (Ladha et al., 2003). A case of South Asia shows that ZT saves 36 liters of diesel for the cultivation of wheat in a hectare, which is 8% less as compared to the conventional tillage (Erenstein & Laxmi, 2008). Similarly, ZT saves water where wheat is grown in the irrigated

condition. Reducing the consumption of water is also associated with decreasing fossil fuel consumption. Moreover, ZT minimizes the decomposition of soil organic matter in the soil which ultimately contributes in reducing the emission of N_2O (Tripathi et al., 2006; Gupta & Sayre, 2007).

2.6.3 Other practices

2.6.3.1 Fertilizer management

To increase fertilizer use efficiency and to reduce emission of GHGs, identification of appropriate fertilizers and their application method is important. For example, the application of urea granules coated with dicyandiamide or calcium carbide and its application matching with crop growth stage not only increases nitrogen use efficiency but also decreases the nitrogen leaching from soil (Denison, 1996). It is because nitrogen releases to the soil slowly from the granules and most of the released nitrogen is absorbed by plants. In addition, botanicals, such as neem (*Azadirachta indica*) seed was found promising as nitrogen inhibitor in urea granule in India. The other option in minimizing the N loss is selection of appropriate fertilizers. The release of nitrogen from amonium sulphate is slower than that of urea. Also, due to the availability of sulphur, ammonium sulphate minimizes the emission of CH_4 from rice field. Similarly, the application of gypsum *(*$CaSO_4$*)* in the rice field reduces the CH_4 emissions by 29–46 % (Domaar, Lindwall & Kozub, 1988).

2.6.3.2 Water and land management

Rice is grown in water retaining soil, and so combining land management techniques with irrigation would increase the water use efficiency, crop yield and mitigate the CH_4 emission from rice-based system. Some land management techniques such as laser land leveling, bed planting, have been promising to increase the water use

efficiency in rice. One study shows that laser land leveling in wheat field in Pakistan saves 25% water (Yadav et al., 2010). Similarly, management of proper drainage and adoption of SRI (System of rice intensification) are other practices contributing on water management. The SRI combines the concept of drainage along with adoption of young (10-14 days old) single seedling, space planting and organic manure application. This technique is being promoted across the rice growing environments; however, its adoption is limited due to weed infestation and higher cost involved in transplanting rice seedling (Upreti, 2008).

2.7 Policies and programs for supporting community-based seed producers in Nepal

2.7.1 Introduction

In Nepal, government agencies and development projects are the major actors involved in supporting CBSPs. This section discusses the policies and programs of these actors with respect to the provision of source seed, seed quality testing facility, and other extension facility (e.g. training) to CBSPs in Nepal.

2.7.2 Policies

Rice research and development activities started in Nepal systematically from 1972 with the establishment of National Rice Research Program at Parwanipur of Bara district, but policies with reference to seed production and its promotion started only after the development of National Seed Act in 1988. After this year, various policy documents have been released from the government even though few of them are focused on seed sector whereas others on agricultural development as a whole.

2.7.2.1 Agriculture Perspective Plan (APP)

This document was prepared and implemented to guide overall agricultural

development in Nepal from 1995 to 2015. The APP is a growth strategy that recognizes agricultural growth as the main factor of poverty reduction in Nepal. The Government approved APP in 1995 and then incorporated in its strategy and planning documents since then. The APP aims at increasing the agricultural growth from 2.5% to 5% and reducing poverty from 49% to 14% over the 20-year plan period. Though the use of good quality seeds of improved varieties is widely recognized as fundamental to ensure increased crop production and productivity in the plan, the strategies to provide good quality seed of the improved varieties have not been mentioned. It also discussed the development of infrastructure such as road and irrigation facility for agricultural development as well as recognized the importance of the participation of private sectors in agriculture but did not indicate the operational mechanism to implement these strategies. APP is still the basis for the agricultural development in Nepal.

2.7.2.2 National Agricultural Policy 2004 (NAP)

This policy has been adopted since 2004 and its focus is on improving the livelihoods of people through transformation of the subsistence agriculture into a commercialized ones. However, the specific objectives are:

- to increase agricultural production and productivity
- to make Nepal's agriculture competitive in the regional and the global markets, through commercialization and competitiveness
- to protect, promote and properly utilize the natural and environmental resources, and biological diversity

In order to raise production and productivity, NAP emphasizes to supply main production inputs (seeds, fertilizers and breeds) based on market demand. It encourages the use of hybrid seeds and regular monitoring of genetically modified organisms. It

talks about the supply of quality inputs. It has provisioned to provide accreditation to private laboratories for testing of seed quality. The policy commits to provide special incentives to *Dalit*, oppressed and marginalized farmers and agricultural labourers who own less than a hectare of land with inadequate irrigation facilities.

Moreover, NAP proposes to establish and strengthen Agriculture Resource Centres (ARC) on the basis of development region as special technology service centres for (a) collection, processing, storage and transportation of agricultural produce, and (b) production of quality seeds, seedlings, plants and breeds of animals and plants. These centres would be gradually strengthened through the provision of trainings so that they could develop into an integrated centre providing services relating to soil analysis, seed certification, diagnosis and management of crop and livestock diseases, and training to entrepreneurs, businessmen, cooperative workers and agricultural workers. In spite of the optimistic policy, no attempt has been made for its implementation in the ground.

2.7.2.3 National Seed Policy 1999 (NSP)

Until 1998, NARC was the only organization to develop crop varieties and supply source seed to farmers. However, NSP opened up avenue to involve private sector in crop variety development and seed trade. The NSP covers seven aspects of seed industry growth in Nepal: 1) Variety development and maintenance, 2) Seed multiplication, 3) Quality control, 4) Increased involvement of private sector, 5) Seed supply, 6) Institutional strengthening, and 7) Biotechnology. The objectives of the NSP were: (i) making available quality seeds of various crops in required quantity, (ii) promoting export by producing quality seed, (iii) making seed business effective in terms of existing world trade, (iv) conserving indigenous genetic resources and coordinating with concerned organization to protect national right on them. Many

provisions in the NSP are progressive towards the development of seed industry in the country by facilitating the involvement of private sector in this area. As in the previous policies there was lack of operational strategies. This policy also suggested amending the Seed Act 1988, incorporating the issues related to the involvement of private sectors in seed production and supply chain.

2.7.2.4 Seed Act 1988 and its first amendment 2008

A seed act was developed in 1988 to regulate the quality seed production in the country so that general public people could improve their living standard by increasing crop yield as a result of adopting improved seed. As per the act, National Seed Board advises Nepalese Government on formulating and executing national policies for ensuring availability of quality seeds through regular production, processing and marketing. The amended document has increased the provision for the participation of farmers from one to two. Similarly, a representative from agricultural development bank will be in the national seed committee consisting of 15 members and headed by Agricultural secretary. Similarly, the revised act has provisioned the licensing to private sector for setting up seed laboratory. But this act has made it compulsory for the registration/release of varieties before going for dissemination or mass multiplication. It does not talk about the farmers' rights towards the indigenous knowledge and varieties evolved through their selection process. Similarly, there is nothing mention about how the plant breeders working with government agencies would realize incentives for the development of more varieties.

2.7.2.5 Three Year Interim Plan (2010-2013)

This plan highlights the necessity for quality seed production by strengthening government-owned and private farms which produce certified seed and improved

livestock breed. It also highlights necessity for developing international level seed certification standard in Nepal so that seeds produced in Nepal could be exported to foreign countries.

2.7.2.6 National Agro Biodiversity Policy (2007)

Nepal is quite rich in biodiversity though the country is small (occupying 0.09% of the world land). The country possesses biodiversity at generic, species and ecosystem level. Biological diversity of Nepal is closely linked to livelihoods, human health and nutrition and indigenous knowledge. This policy provides overall policy framework for agricultural biodiversity conservation in Nepal. It provisions to carry out research activities on genetically modified organisms but those interested to do so need to take permission from government showing its impacts on biodiversity and environment. It highlights the necessity of recognizing the farmers' rights in local varieties and materials but does not discuss about the mechanism to do so.

2.7.2.7 Local Self Governance Act (1999)

The Local Self-Governance Act 2055 (1999) authorises the local bodies such as VDC, District Development Committees and municipalities to formulate and implement policies, programs related to agriculture and rural development. Agricultural related activities highlighted in this act are promotion of agricultural market centres, animal clinics and irrigation facility. It also stressed that VDC be the focal body to coordinate field level agricultural activities to be implemented by government and NGOs.

2.7.3 Programs

2.7.3.1 Foundation seed production and its supply

NARC has prime responsibility for the production of breeder seed in Nepal, and this category of seed is produced at National Rice Research Program and at other NARC

stations. NARC is also the primary legitimate organization to supply foundation seed though in recent years (from 2000-2010), six private firms have taken the license for producing foundation seed. Table 2 presents the summary of foundation seed (also called as source seed) produced in the country against its requirement at the national level. The data are only from NARC stations as private agencies have not started supplying foundation seed in rice.

Table 2.1 Foundation seed supply situation of major food crops in Nepal

Crop	Area (000ha)	Annual requirement (t)	Quantities of seed certified (t)					
			2004	2005	2006	2007	2008	2009
Rice	1,549	19,362	229.1	193.9	232.2	244.5	327.3	253.0
Maize	870	6,090	17.7	12.9	17.1	6.7	10.6	124.8
Wheat	706	21,180	118.4	70.6	92.7	88.9	180.1	43.6
Lentil	265	1,988	0.96	NA	0.2	2.5	1.02	NA

Source: MoAC, 2009

2.7.3.2 Seed quality testing

In accordance with the seed act (1988) and seed policy (2000), seed testing laboratories have been established in each of the five development regions of Nepal. These laboratories provide seed testing facility for seed producers. In addition, officers from these organizations monitor and inspect of seed crops at field, carry out survey activities to understand the study situation in the country, certify seed plots and storage, collect local landraces, and awareness raising about seed production and marketing. Limited human resources (two officers and 3-4 technicians in each lab) and physical facilities for seed quality testing are the major bottleneck faced by these laboratories. Since laboratories are located in city areas, visiting these laboratories for farmers have time and cost implications. Also, due to scattered seed plots and limited human resource, laboratory staffs rarely make field monitoring on time. Considering this challenge, Nepalese government has started giving seed inspection license to the agricultural

professional in recent years. Until 2010, four private organizations have already taken the licence for seed quality testing (SQCC, 2012). However, the performance of these organizations is yet to be assessed.

2.7.3.3 Community-based seed production

The first program implemented by Nepalese government to support community-based seed production is the District level Seed Self Sufficiency Program (DISSPRO). This program was implemented by Ministry of Agriculture and Cooperative since 1998. Initially, this program was implemented in 15 districts, two tarai and one hill district in each of the five development regions (Poudel et al, 2003). The selected districts were to produce certified first generation (C_1) seed from source supplied by research stations. As of 2012 this program has been extended across the 63 districts (SQCC, 2012). In this program DADOs and its subsidiary organizations such as agriculture service centres are the major actors for its implementation. As per the DISSPRO guideline DADOs provide necessary technical support (through training) in producing, processing, storing and distribution of seed, for the selected CBSPOs registered in DADOs. Farmers participating in this programme get 25% subsidy on source seed together with 100% subsidy on transportation. The recipients are the households maintaining good relationship with DADOs' officials. It means those having good relationship with government officers are more likely to get these facilities. Moreover, households could also get 25% subsidy on sprayers and pesticides' cost.

In addition to the above-mentioned household level benefits, DISSPRO provides grant NRs 25,000 to start their business activities for one group but the total number of groups (CBSPOs) receiving such grant were 20 by 2009 as a start-up business support fund, but the total number of organizations receiving this support was 20 by 2009. With

the aim of making DISSPRO more commercial oriented, some additional support schemes have been provisioned under DISSPRO. These schemes are supports for irrigation facility, and partial grant for developing physical structures such as threshing floor and seed storage house. CBSPOs receiving these supports are from Chitwan, Rupandehi and Morang districts.

There is no comprehensive study carried out to evaluate the DISSPRO program in a country as a whole. But district level case studies (Poudel et al., 2003; Chand & Karki, 2005) shows that DISSPRO was only focused on production aspects rather than empowering farmers about seed marketing. Also, donor-funded projects implemented by DADO under DISSPRO framework realized the same problem (Poudel et al., 2003). For instance, Special Project in Nepal (SPIN) was implemented in six tarai districts of Nepal from 1995-1999 to enhance farmers' level seed production in food crops including rice by DADOs but none of the CBSPOs out of 20 surveyed were continuing seed production activities while visiting in 2001.

The main reason behind it might be due to lack of marketing knowledge as the project provided training only in production aspects (Chand & Karki, 2005). Similarly, the second reason might be due to poor linkage of CBSPOs with service providers. It was due to the fact that the project provided necessary seed, fertilizer and pesticides to the farmers on subsidy after buying in the market mobilizing the project staff, but no attempt was made to link the market actors with CBSPOs. Other associated reasons might be due to poor access to credit facility in the rural areas. In Nepal, rural finance includes agricultural finance, microfinance, cooperatives and other informal sources such as village merchants, friends and relatives. The service of formal financial institution is concentrated in city areas and these institutions hesitate to lend money to

seed enterprises run by farmers. Therefore, CBSPOs have to pay exorbitant interest rates putting their collaterals such as land certificates, even if financial institutions agree to provide them loans (Pradhan, 2009).

In addition to the government's led programs, several donor-supported projects were also implemented by NGOs in partnership with government agencies to help establish the local seed supply system in the country. Some of the projects to enumerate are: Seed Production and Inputs Storage Project, Private Producers Sellers Programme, Mechi Hill Development Programme, Koshi Hill Seed and Vegetable Development Project, Rural Save Grain Project, Seed Sector Support Project, Hill Seed Programme, Action Aid Rural Development Programme for Seed Production, and seed production program run by Pakhribas Agriculture Center and Lumle Agriculture Center.

All of these projects were implemented in the hills to support local seed supply system in vegetables and cereal crops. There are no impact evaluation studies of these projects but it is believed that they created awareness and provided basis for the development of seed industry in the country. Similarly, these projects were focused on not only seed but also the other aspects of livelihoods in the rural areas. These projects were also primarily followed the strategies followed by DISSPRO where previously formed groups, cooperatives with no or limited business skills were strengthened in seed production and marketing. The recent projects focused on community-based seed production in cereals and legumes in tarai was Research into Use Program (2008-2012) which emphasized the empowerment of farmers' groups and cooperatives through enterprise management training, facilitation for the development and operation of business plans, and fostering linkage with other service providers and communities (Forum for Rural Welfare and Agricultural Reform for Development - FORWARD, 2011).

Chapter 3. Research design

3.1 Introduction

This chapter describes the conceptual framework used to analyze the sustainability of community-based rice seed production. These concepts were developed based on the existing literature about what makes this seed production system successful. In addition, this chapter highlights the study districts, methodology for gathering and analyzing data.

3.2 Conceptual framework

There are two approaches used to analyze the sustainability of rural agricultural systems: a) comparing the performance between successful and unsuccessful systems, and b) comparing the performance between better performers with lower performers. This study adopts the second approach for analyzing the sustainability of community-based seed production system. Another issue in the analysis is what needs to be sustained. This study considers that benefits to be realized by producers and consumers need to be sustained as it might not be logical to consider the continuity of the system elements in the same level in the changing context (Brinkerhoff & Goldsmith, 1990). The benefit realized by seed producers are analyzed from the perspective of efficiency both in 'seed production' and 'seed marketing' phases.

3.2.1 Components of the framework

Producers: Producers represent rice seed producing households having membership in CBSPOs. Since seed production is carried out household level, it is the household decision how household converts inputs (land, labor, capital and source seed) into raw seed using technology (scientific knowledge) and achieve economic and environmental performance. The economic performance gained by household is efficiency, whereas environmental performance (here it is adoption of soil conservation practice) shows the

basis for continuing efficiency for long time. After producing raw seed, household supplies it to their organizations (CBSPOs) for marketing (market research, collection, processing, storage and distribution). Then, CBSPOs convert it into processed seed, and sell seed to the consumers. The performance of CBSPOs in marketing can be measured in terms of efficiency and governance. The performance of CBSPOs in marketing also represents the performance of households because organization is the mechanism to achieve households' objective. The governance of CBSPOs is mainly related how the organizations form rules and regulations in line with achieving efficiency in marketing. Good governance in the organization is also needed to manage conflict/risks that emerge from internal and external factors. This is because it defines incentive system for members to work for their benefits in a collective way. Governance also affects the flow of information within the organization, and makes the basis for implementing monitoring and evaluation system. Moreover, it also guides how democracy is implemented in the organizations. Participation of member in the decision making process is the major way of applying democratic principle in the organization. However, it is integrated in the governance system as a means to reducing risk against inefficiency of organization in rice seed marketing

Consumers:

Consumers are also rice farming households residing near the seed producers but they grow rice for food and not for seed.

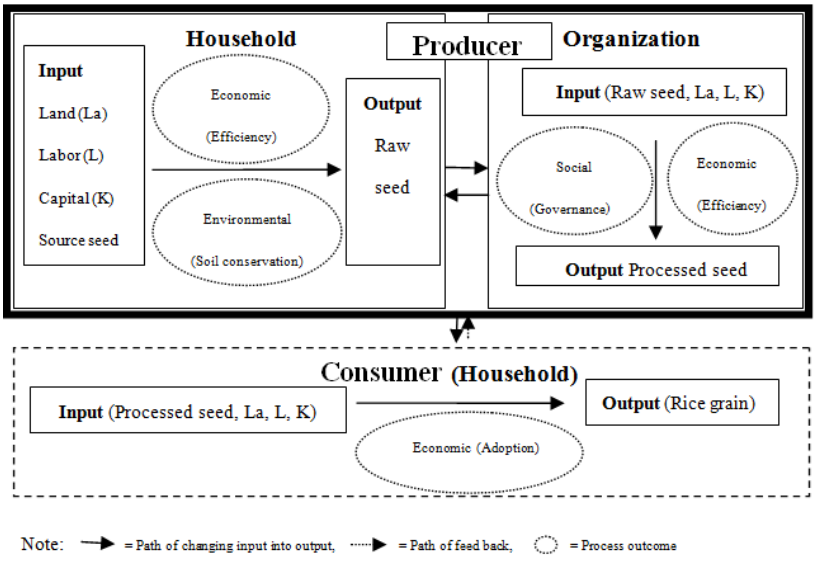

Figure 3.1 Conceptual framework of the study

These households serve as potential buyers of seed produced by the seed producers. These farmers might get processed seed from CBSPOs and convert it into rice grain using internal resources. In the process of conversion if they realize benefit it is more likely that the consumers would continue buying seed from the seed producers (adoption). The benefit might be in the form of crop yield, straw yield or suitability of rice varieties in the cropping pattern or market price. However, diversity and cheap price could address the consumers' concerns. The adoption of seed/variety is an economic issue, and environmental and social issues are not focused at this level.

3.2.2 Relationship between producers and consumers

Three theories (system theory, contingency theory and political economy) explain the relationship between producers and consumers. The system theory discusses how formal collectivities to informal code of conducts work in the process of converting source seed into processed seed. Secondly, system theory is concerned simultaneously with the internal process and the relationship between the system and its environment. It thus forces us to think about a wide variety of social, economic, political, technical and other factors that affect sustainability. In other words it enables us to merge agro-environmental, economic and managerial aspects in sustainability analysis.

System theory, however, provides little guidance about how to portray internal system processes or changes in response to externality. It is because the optimal structure or management styles of the production system are contingent on uncertain and exogenous condition. Contingency theory thus shares with system analysis a concern for environment. The assumption in the theory is that any human aggregation or pattern of behavior has to be seen in relation to the complex of outside forces that threaten or promotes its survival and expansion. The contingency theory fills this gap

and demonstrates how producers can best attain congruence with the influences of external factors.

Producers can also impart direct influence on consumers. For example, marketing strategies such as seed quality, quantity, location, time of distribution, publicity could change consumers' behavior in buying seed. But it is difficult for household to do these activities individually but they could do while organizing in groups or organizations. The households' phenomena to organize in groups/association can be discussed with the help of political economy. For example, farmers organized in organizations could improve their economic activity by reducing transaction (marketing) cost and enhancing bargaining power with service providers. So, the above framework addresses three pillars (economy, environment and society) of sustainable development.

3.3 Study districts

The study was carried out in three tarai districts: Siraha, Chitwan and Kailali of Nepal, and these districts represent Eastern, Central and Far-western development regions of the country, respectively. The commonality across the districts is that agriculture is the major source of livelihoods of people (Table 3.1). The location of these districts in Nepal's administrative map is shown in figure 3.2.

The farmers in these areas are poor (with per capita income less than one dollar a day), and small farmers (average landholding less than a hectare). Also, majority of people in these districts are illiterate. Chitwan has better irrigation facility as compared to that of other two districts. This district has also better road networks with other parts of the country.

Table 3.1 Characteristics of the study districts

Characteristics	Siraha	Chitwan	Kailali
Land area (sq km)	1,228	2,238	3,235
Cultivated land (%)	60.9	44.3	27.5
Irrigation land (%)	24.8 (21.9)	52 (34)	42.2 (23.3)
Average holding per household	0.721	0.552	0.994
Average family size per household	5.6	4.27	5.26
Annual per capita income (NRs.)	9,257	10,780	6,824
Literacy (%)	42.2	51.0	37.4
Households adopting agriculture as major source of livelihood (%)	80.5	70.0	79
Rice production area (ha)	32,770	45,570	60,000
Rice yield (tha^{-1})	2.1	3.38	2.9

Figures in the parenthesis indicates % of land having year round irrigation facility (Source: CBS, 2011b).

Figure 3.2 A Map of Nepal showing the study districts

Source: http://www.un.org.np/resources/maps

Moreover, there is variation in rainfall pattern across the districts. Siraha is more drought prone area, Kailali is flood prone district, and Chitwan falls under medium category (Ministry of Environment – MoE, 2010). Trend analysis of rainfall during rice growing season in these districts from 1976 to 2010 also shows that total rainfall during rice growing season (June-September) in Chitwan and Kailali is in increasing trend

whereas it is decreasing in Siraha (Figure 3.3). July represents rice seed transplanting time and if farmers do not get rainfall in this month it might be difficult to transplant rice seedling on time and it might have negative consequence on rice yield and its quality. The trend shows that amount of rainfall in July is in decreasing in Siraha and Chitwan but it is in increasing trend in Kailali. Similarly, rainfall during rice harvesting time (October) is considered challenging for CBSPs because it could deteriorate rice seed quality. There is increasing rainfall pattern in Chitwan and Kailali but it is in decreasing trend in October. Since rice seed production is carried out in the open field situation, higher amount of rainfall during this month might reduce the seed quality.

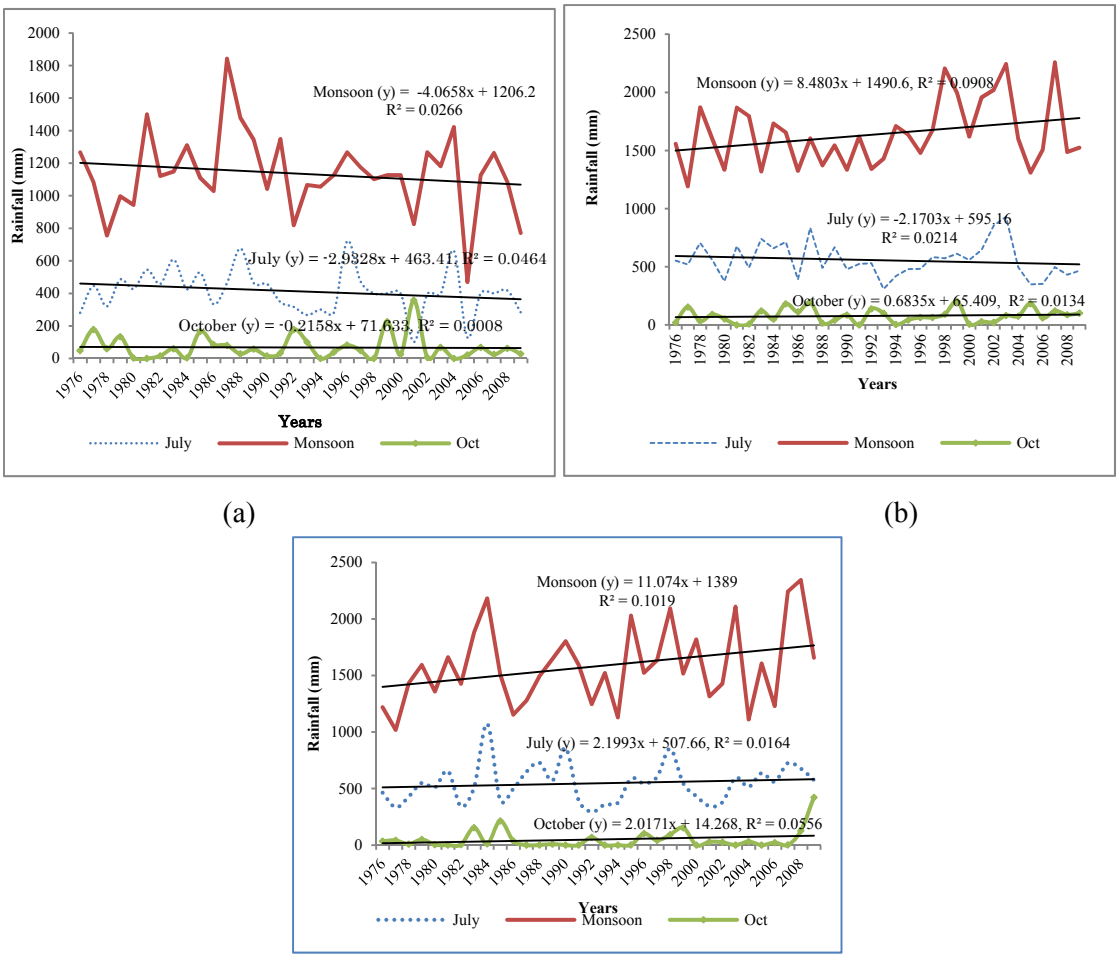

Figure 3.3 Rainfall trend of study districts: Siraha (a), Chitwan (b) and Kailali (c)

Source: Raw data from department of Hydrology and Meteorology – DHM (2011)

3.4 Source of data

This study mainly uses the primary data collected from the household and institutional survey carried out from October to November 2011. To complement these data, information collected from books, reports, journal articles were utilized.

3.5 Sampling design

The study employed multi-sage random sampling technique while selecting the households for the study. However, the there is slight different in the sampling technique employed in seed growers and seed consumers.

3.5.1 Seed growers

This sampling strategy was used for selecting seed producers and is related to chapters 5, 6, 7 and 8. A total of 12 CBSPOs, four in each of the above-mentioned three districts were selected for the study. To select the CBSPOs, a list of CBSPOs registered in DADOs, and having at least two years experience in rice seed production and marketing were chosen. Since the number of registered CBSPOs fulfilling the aforementioned criteria was quite limited (Chitwan = 10), Kailali (6) and Siraha (5), four CBSPOs in each district were randomly selected for the study. Since all the members of the selected CBSPOs were not involved in rice seed production, only 15 rice grown members in 2010 were randomly chosen for the study. So, the total number of households chosen for survey was 180. The list of CBSPOs chosen for the study is presented in Appendix 1.

3.5.2 Seed consumers

As discussed previously the potential consumers of seed produced by CBSPs are also the farmers who grow rice but for grain purpose (for food). So, the adoption study of improved rice varieties was carried out in the areas located nearby the producers

(Figure 3.4). In this case, after selecting CBSPOs (3.4.1), one VDC adjoing to the selected CBSPO was chosen. Then, one village in each of the selected VDCs was selected using the criteria that farmers were not engaged in CBSPOs. Fifteen households were selected from each village making the total of 180 households for field survey. Moreover, one group discussion in each village was also organized to get information that complements household survey. The detail of the surveyed villages and VDCs is given in Appendix 2.

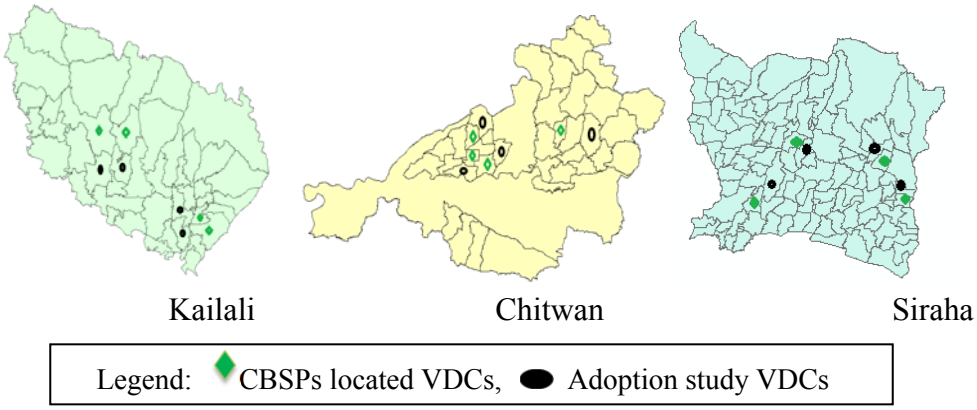

Figure 3.4 Surveyed VDCs in the selected districts

3.6 Data analysis

The study uses both descriptive and econometric methods in data analysis using the statistical software STATA 9. The descriptive statistical techniques are mean, standard deviation, percentage; whereas, econometric tools are stochastic frontier production model, ordinary least square regression, binary logistic regression, multivariate probit, and heckman selection.

3.7 Limitation of the study

In sustainability analysis, it is important to demarcate the boundary of the research and integrate the triple bottom line indicators (economy, ecology and society) in the selected layers. In this research, two layers (household level and organization level)

were considered in the analysis at producer side whereas one layer (seed consuming household) considered in consumer side. It does not mean that rice seed value chain ends at seed consumers but at grain consumers. The grain consumers will be not only the rice growing farmers but also those who do not grow rice but involve in its transaction and consumption. The latter two actors' concerns have not been analyzed in this study. However, it is hypothesized that seed consumers' concern of price reduction and variety diversity could also capture these actors' concerns as well. Similarly, due to absence of soil analysis data, ecological indicators such as adoption of soil conservation practice, was used to represent environment concern in rice seed production.

Chapter 4. Adoption of improved rice varieties

4.1 Introduction

Seed consumers in this study are farmers those growing rice for grain and not for seed. So, they act as buyers of the seed produced by seed producers. So, farmers' (consumers) behavior in buying seeds play important role in the profitability and sustainability of community-based seed production. From economic perspective it can be argued that farmers' behavior depends on how they value for seed. It is clear from the literature that people buy seed for improved variety or improved seed (Joshi & Bauer, 2006; Paudel, 2011; Kafle, Paudel & Ghimire, 2012). However, there is no specific clear cut demarcation between these two terminologies. Professionals working in agricultural research and extension agencies use this term to refer to the modern varieties those developed by agricultural research organizations, and improved seed for the seed of these varieties. People from these backgrounds generally have mindsets that varieties developed from research stations are always superior to what farmers grow or innovate (farmers' varieties).

On the other hand, the meaning of improved varieties might be different for farmers as they consider multiple aspects such as suitability of seeds in the cropping pattern, agronomic characteristics of the varieties, market potential and so on. Similarly, another problem in the rice variety adoption analysis is that whether farmers repeatedly buy fresh seed of the same variety or go for new variety. To address these complexities, improved varieties are defined as those which farmers buy from the market. It means farmers' behavior in valuing the seed/crop varieties can be captured by this market-based measure. So, this definition captures both modern varieties and farmers' varieties. This chapter analyzes the types of varieties farmers buy from the market,

sources of these varieties, and impacts of households' socio-economic determinants for the adoption of these varieties.

4.2 Rice varieties grown in the study area

The study shows that farmers adopt 17 different rice varieties in the study area in the growing season of 2010 (Table 4.1). These varieties can be divided into modern varieties (58.8%) and farmers' varieties (41.2%). Out of the total modern varieties (10), only 50% varieties (Savitri, Hardinath 1, Ramdhan, Mithila & Radha 4) are the released varieties by Nepalese government; whereas, the other four modern varieties (Kanchhi Masuli, Sarju 52, Sona Masuli and Sawa Masuli) are the ones released by Indian government in 1970s, and these Indian varieties introduced in Nepal's tarai districts through informal channel (farmer to farmer contact) due to open boarder system between Nepal and India. But according to amended seed act of Nepal (2008), growing of non-registered / non-released varieties is illegal (SQCC, 2012). So, farmers do not get extension facility in these varieties.

Recently (since 2005) farmers in Chitwan and Kailali have started growing hybrid rice variety (Gorakhnath), and agrovet introduced this variety in the study area in partnership with multinational companies. It means multinational companies have started pushing hybrid rice varieties providing incentive (subsidy) to agrovets. The subsidy is in the form of providing seed in credit to agrovet, commission on the seed sold by agrovets and provision of trainings to hybrid seed consumers. The farmers' varieties grown in the study area are Bangali Masuli, Bhale Masuli and Mala (in Siraha), Local Masuli (in Chitwan), and Bans Dhan and Anadi (in Kailali). The study also shows that the average yield of farmers' varieties is (3.12t ha^{-1}) 16% less than those of modern rice varieties released by Nepalese government (3.62t ha^{-1}). But better cooking quality

such as taste (e.g. Anadi), and adaptation in stress condition (such as drought tolerance, e.g. Bans Dhan) have made these varieties popular in the study area.

Table 4.1 Average area (ha) and yield (kg ha^{-1}) of different rice varieties across the districts

Varieties	Area/yield	Chitwan	Siraha	Kailali	Overall
Savitri	Area	0.42 (55)	0.20 (3.3)	0.43(10)	0.41(22.7)
	Yield	4,250	3,240	4,160	4,156
Hardinath 1	Area	0.25 (10)	0.21 (10)	0.18(3.3)	0.21(7.2)
	Yield	3,879	2,875	3,689	3,298
Ramdhan	Area	0.23(26.7)		0.18(3.3)	0.23(10)
	Yield	4,568		4,381	4,462
Mithila	Area		0.10 (1.6)	0.30(11.7)	0.28(4.4)
	Yield		2,685	2,732	2,694
Radha 4	Area	0.27 (20)	0.20 (5)	0.71(10)	0.38 (11.7)
	Yield	3,526	2,890	4,263	3,492
Kanchhi Masuli	Area	0.11(1.6)	0.52(65)		0.52(22.2)
	Yield	3,548	3,248		3,284
Sarju 52	Area			0.61(81.6)	0.61(27.2)
	Yield			5,281	5,281
Sona Masuli	Area	0.66 (1.6)	0.39 (53.3)		0.39 (18.3)
	Yield	4,560	4,060		4,160
Sawa Masuli	Area	0.34 (20)	0.83 (3.3)		0.41(7.7)
	Yield	4,235	3,685		4,167
Gorakhnath (hybrid)	Area	0.25 (16.7)		0.18(3.3)	0.24(6.7)
	Yield	5,570		6,250	5,892
Farmers' variety	Area	0.26 (11.6)	0.23 (31.6)	0.59 (23.3)	0.40 (22.2)
	Yield	3,524	2,546	3,875	3,125
Mean rice area		0.58	0.91	0.86	0.78

Note: Value in the parenthesis indicate % of farmers Source: Survey, 2011

Similarly, the modern varieties introduced from India produce 4.22t ha^{-1} (35.2% higher yield than farmers' variety), and the yield of hybrid variety is 5.89t ha^{-1}(86% higher than that of farmers' varieties). There is also variation in the distribution of

improved varieties across the district. For example, Savitri is widely grown in Chitwan (adopters 55%), whereas the adoption of Kanchhi Masuli in Siraha (adopters 65%) and Sarju 52 in Kailali (adopters 81% farmers) is high. The popularity of these varieties is specific in the specific location (district). This might be due to variety and environmental interaction in the adaptation (Rana et al., 2007). For example, in case of Chitwan, farmers argued that the main reason for the popularity of Savitri in the district is due to its tolerance to leaf blast and bacterial leaf blight diseases. In case of Siraha where drought has been a serious concern, Kanchhi Masuli has been popular. Farmers argue that this variety has better adaptation in the drought condition as compared to modern varieties released by Nepalese government. Similarly, one of the reasons for wide popularity of Sarju 52 in Kailali is due to its better tolerance to flood and drought as per the farmers' opinion.

As shown in Table 4.2, 72.7% of the sampled households were found to have grown improved rice varieties, but the proportion of households adopting improved rice varieties (against sampled households in the district) is higher in Chitwan (85%) which is followed by Siraha (73.3%) and Kailali (60%).

Table 4.2 Distribution of households growing rice varieties across the districts

Categories	Chitwan	Siraha	Kailali	Overall
Only one variety	5 (9.8)	10 (22.7)	8 (22.2)	23 (17.6)
Two to three varieties	35 (68.6)	26 (59.1)	20 (55.6)	81 (61.8)
Four or more	11 (21.6)	8 (18.2)	8 (22.2)	27 (20.6)
Total adopters	51	44	36	131

Figures in the parenthesis indicate percentage of farmers with reference to district total adopters

Source: Survey, 2011

Similarly, it was found that majority of the farmers (>80%) grow two or more than two improved rice varieties in their farm. Farmers' growing single variety and those

growing four or more than four varieties are 17.6% and 20.6%, respectively. The above finding shows that most of the farmers adopt diversified rice varieties. The practice of diversifying the rice varieties by farmers (specifically on subsistence farming) is also common in the developing countries as variety diversification strategy minimizes the risk of crop failure due to natural calamities or diseases / pests severity (Almekinders, Louwaars and Bruijin. 1994; Gauchan,Smale and Chaudhary, 2005). In group discussions, some farmers argued that another reason for diversifying varieties at household level is to enhance the productivity of overall farming system. For example, early duration varieties such as Radha 4 (maturity 125 days) and Hardinath 1 (maturity 110 days) have been grown by farmers in upland (good drainage) area where they plan to grow winter vegetables (such as cauliflower, potato, radish, leafy vegetables, etc) after harvesting rice. Growing vegetables after harvesting these early rice varieties allows farmers to produce these vegetables about 15-30 days earlier than they do with medium duration varieties. Vegetables produced early could fetch better price in the market because they could be during festivals when people have general tendency to consume higher amount of vegetables. But in the medium or low land areas they choose longer duration rice varieties (maturing from 130-140 days after seed sowing). In general, grain yield and straw yield of medium duration rice varieties is higher than those of early duration varieties (Yadav et al., 2005; NARC, 2011).

4.3 Sources of improved rice varieties

The study shows that farmers buy seed from four sources: neighboring farmers (81.67%), local agrovet (49.6%), CBSPOs (24.4%) and development projects (19.08%) implemented by government and NGOs. It means farmers buy seed from multiple sources though neighboring farmers is the most important source. The agrovet buys

seed from CBSPOs (of all the varieties except hybrid varieties) and sell to farmers using different packaging sizes (1kg, 5kg, and 30kg). Though being the residence of nearby VDCs from CBSPOs, less than one third of the farmers visit CBSPOs to buy seed (Table 4.3). It was found that development projects still play vital role in supplying improved rice varieties in Siraha and Kailali districts. These projects buy seed from CBSPOs or agrovets to distribute to the farmers (who grow rice as grain), and they give preference to the varieties released by Nepalese government.

Table 4.3 Sources of improved rice varieties in the study area

Source of seed	Chitwan	Siraha	Kailali	Overall
Neighboring farmers	40 (78.4)	35 (79.5)	32 (88.8)	107 (81.67)
Local agovet	30 (58.8)	16 (36.3)	19 (52.7)	65 (49.6)
CBSPOs	10(19.6)	12 (27.2)	10 (27.7)	32 (24.4)
Development projects	2 (3.9)	12 (27.2)	11 (30.5)	25 (19.08)
Total adopters (n)	51	44	36	131

Note: Figures in the bracket show the percentage of the total adopters. The percentage of total adopters would be more than 100 because farmers could buy seed from more than one source, Source: Survey, 2011

4.4 Factors affecting the adoption of improved rice varieties

4.4.1 Conceptual framework for analyzing the improved rice varieties

From economic perspective it could be argued that farmers buy seed from the market if these provide economic benefit to them. But it is difficult to precisely estimate the total economic benefits farmers tend to get from improved variety adoption because only grain yield might not be the concern for the acquisition of improved varieties. Other traits such as resistance/tolerance of the varieties to diseases, suitability of the varieties in their cropping system, quality and quantity of straw (for livestock feeding) and so on might be the important considerations for farmers. All these situations make it difficult to model the household's behavior to buy the seed directly. Rather it could be

done from the perspective that farmers develop some perception towards the variety by analyzing the potential benefits/cost while adopting the varieties in the cropping system and decide for their adoption. It can be further discussed with the help of Rogors' (1995) diffusion theory which explains that adopters go through the five stages (awareness, persuasion, decision to adopt/test, implementation and feedback) in the adoption/diffusion process and develop perception towards the varieties. The perception is influenced by various factors such as demographic, economic, social and institutional factors (Gauchan, Smale & Chaudhary, 2005; Joshi & Bauer, 2006; Tiwari et al., 2008). This concept addresses the farmers' behavior to buy both modern and farmers' varieties (Paudel & Matsuoka, 2008).

4.4.2 Empirical model

A binary logistic model (BLM) was used to see the impact of socio-economic variables on the adoption of improved rice varieties. Since the dependent variable is binary (i.e. 1 if farmers buy rice seed from the market and 0 for otherwise), the BLM is suited for the analysis. Although linear probability model such as Ordinary Least Square (OLS) can be used to analyze binary choice model, certain assumption of classical regression are violated. They include non-normality and heteroscedastic error, and questionable R^2 as a measure of goodness of fit. Logit and probit models have been developed to address these issues; however, logit model is preferred if the choice variables are mutually exclusive with each other (Long & Freese, 2006). Previous researchers (Joshi & Bauer, 2006; Paudel & Matsuoka, 2008) were also adopted BLM to analyze the adoption of improved varieties. Theoretically the BLM is given in equation 4.1 (Agresti, 1996).

$$\text{Ln}\,(P_x/(1-P_x)) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots\ldots\ldots \beta_k X_{ki} + \varepsilon_i \quad \ldots\ldots(4.1).$$

Where, Ln is log, i is the i^{th} observation in the sample, Px is the probability of farmers buying seed from the market in consideration of the given explanatory variables ($X_{i,}$) and (1-Px) is the probability of non-adoption. β_0 is the coefficient of intercept and β_1, β_2…….. β_k are parameters to be estimated, k indicates the types of explanatory variables, and ε_i is error term. Since the BLM is estimated through maximum likelihood method, the coefficients do not show the average impact of independent variables on probability of adopting improved varieties. So, marginal effect of socio-economic variables on dependent variables was estimated after estimating the BLM (Sheikh, Rehman & Yates, 2003). The marginal effect values are used to discuss the influence of explanatory variables in the probability of adopting improved rice varieties.

4.4.3 Specification of the model and variables

With reference to the theoretical model given in equation 4.1, the operational model used in the study is specified in the equation 4.2.

Y = $\boldsymbol{\beta_0}$ + $\boldsymbol{\beta_0}$ + $\boldsymbol{\beta_1}$ **lnage of HHH** + $\boldsymbol{\beta_2}$ ln education of HHH + $\boldsymbol{\beta_3}$ ln family labor + $\boldsymbol{\beta_4}$ ln off-farm income + $\boldsymbol{\beta_5}$ **ln operational land** + $\boldsymbol{\beta_6}$ **ln livestock** + $\boldsymbol{\beta_7}$ ln chemical fertilizer + $\boldsymbol{\beta_8}$ irrigation dummy + $\boldsymbol{\beta_9}$ CBO dummy + $\boldsymbol{\beta_{10}}$ ln seed price + $\boldsymbol{\beta_{11}}$Chitwan dummy……(4.2)

Here, Y represents the binary dependent variable (0, 1). Explanatory variables were selected considering adoption theory, previously carried out studies and field situation. These variables are classified as demographic (age and education of household head –HHH, and family labor), economic (off-farm income, operational land, livestock,

chemical fertilizer, irrigation, seed price) and institutional (household's membership in community-based organizations- CBOs). The description of the explanatory variables and their hypothesized influence on the adoption of improved rice varieties is summarized in Table 4.4.

Since HHH is the major decision maker at household in Nepal, its characteristics might influence household's decision for the adoption of improved rice varieties. It was hypothesized that younger HHH might be better in adopting improved varieties as compared to their counterparts considering their better linkage with market (Paudel & Matsuoka, 2008). It was hypothesized that education of HHHs might have positive impact on the adoption of improved varieties considering that higher educated people could have better access to extension facility about the improved seed and associated production technology (Joshi & Bayer, 2006), and they could analyze the potential benefits and costs while adopting improved rice varieties in a better way than their counterparts do. Family labor is an important source of input in subsistence farming and it was hypothesized to have positive influence in the adoption of improved rice varieties. Households with higher family labor are more likely to implement the field activities on time (planting, such as weeding, fertilizer application), and it results to increase in yield (Paudel & Matsuoka, 2008; Paudel, 2011).

Among the economic variables, household's off-farm cash income was assumed to have positive impact on improved varieties adoption. It is because access to credit is still challenging in the study area as most of the bank and micro-finance services are located in the cities, and it is difficult to access credit for small farmers in these areas (Pradhan, 2009). It was hypothesized that those having access to off-farm income could easily get cash and it might be used in buying necessary inputs for rice production, and

carrying out crop husbandry activities on time. Similarly, operational land holding was considered to have positive influence on the adoption of improved varieties as households with larger operational holding might have higher risk bearing capacity, and motivation to increase the yield by combining other agricultural inputs. It was assumed that operational landholding would positively influence households for the adoption of improved rice varieties (Tiwari et al., 2008). Livestock is the integral component of Nepalese farming system and farmers use all the manure at their fields whatever produce at household, so livestock standard unit (LSU^3) was calculated and it was used as a proxy variable to represent the amount of manure applied in rice fields. Livestock was assumed to have positive influence on improved rice varieties adoption. In addition to animal manure, farmers use chemical fertilizer, and it was hypothesized that chemical fertilizer could have positively influence on the adoption of improved varieties due to positive linkage of chemical fertilizer with crop yield increment (Paudel & Matsuoka, 2008; Regmi et al., 2009). Similarly, it was hypothesized that access to irrigation source could have positive influence on improved rice varieties adoption. The price of rice seed was hypothesized to have negative influence on improved variety adoption in accordance to the micro-economic theory.

Institutional variable included in this study is the household's membership in agricultural group or cooperatives and these institutions are termed as CBOs in this study. These CBOs are farmers' groups and cooperatives for the socio-economic empowerment of their members through self-help approach. Being membership in CBOs, farmers intend to access agricultural training and improved varieties as extension policy of government and NGOs is group-oriented in Nepal. So, those having membership in CBOs are more likely to access extension facility from these agencies,

and subsequently it might have positive influence on improved variety adoption (Tiwari et al., 2008). As discussed in the methodology section Chitwan district has better infrastructure and extension facility as compared to the other two districts. These factors would be additional sources of variation in the model and could distort the result. To address this issue, Chitwan (location) was used as a dummy variable while running the model.

As per the regression rule, diagnostic tests were carried out to check the heteroscedasticity and multicollinearity problem in the data. For this, selected explanatory variables were regressed against the dependent binary variable using OLS. Then, variation inflation factor (VIF) test was carried out to check multicollinearity among the variables. Since the VIF value for the dependent variables remained below 10 suggesting no problem of multicollinearity. Breusch-Pagan/Cook-Weisberg test was carried out to test for the heteroscedasticity and the hypothesis of heteroscedasticity was strongly rejected (p value below 0.004).

Table 4.4 Description of explanatory variables used in the model

Variables	Definition	Expected sign
Age of HHH	Age of household head (years)	-
Education of HHH	Formal education of HHH (years of schooling)	+
Family labor	Labor force unit (LFU)[2] at household	+
Off-farm income	Annual cash income from off-farm sources (NRs)	+
Operational land	Operational land under rice production at household (ha)	+
Livestock	Livestock standard unit (LSU)[3] at household	+
Chemical fertilizer	Total cost of chemical fertilizer (NRs ha^{-1})	+
Irrigation	1= if farmers' have access to public irrigation facility,0 for otherwise	+
Membership in CBO	1= if any member of household has membership in farmer group/cooperative, and 0 for otherwise	+
Price	Price of rice seed (NRs kg^{-1})	-
Chitwan	1 = farmers from Chitwan district, and 0 for otherwise	+

4.4.4 Results and discussion

4.4.4.1 Summary of study variables

Table 4.5 shows the summary statistics of socio-economic variables of the households included in binary logistics model with reference to their mean and standard deviation. Aerage age of HHH is 41.9 years but it varies across the households. The majority (96%) of the HHHs attended formal schooling and but their average formal schooling years was 5.2 (primary level of education). The average labor force at household is 3.2, but varieties from 2 to 15.

In this study households represent small farmers with average operational holding of 0.78ha (range 0.06 - 4.67ha) which is similar to the national average (0.8ha). People in the study area make their livelihoods both from on-farm (agriculture) and off-farm (business, salaried job, remittance) activities. Annual average cash income of the households is NRs 59,922. Only 63.3% of the households get cash income from agriculture, whereas 66.67% of households receive cash income from off-farm sources. The average off-farm income of households is NRs 49,531 and it varies from NRs. 4,780 to NRs 122,600 per year. Livestock is the integral part of farming system in the study area. All the households were found to have raised livestock, and average LSU in the study area is 3.46 but it varies from 0.5 to 201. Cow, buffalo, goat, poultry and pig are the major livestock species being raised by farmers.

In addition to animal manure, 90% of farmers apply chemical fertilizers in rice field. The sources of chemical fertilizers are urea (nitrogenous fertilizer having 60% N), Diamonium Phosphate (DAP- having 18% N and 48% P) and Muriate of Potash (having 60% K). It was found that the amount of chemical fertilizers applied by farmers in rice field is N: P: K:: 41.9: 28: 9 kg ha^{-1} and this doze is smaller than the recommendation

made for irrigated rice in tarai region of Nepal (N: P: K:: 100: 30: 30kg ha^{-1}) (MoAC, 2010). We used chemical fertilizer cost (NRs) to represent the amount of chemical fertilizer applied in rice field. On average farmers apply chemical fertilizer with the cost of NRs 5,244ha^{-1} and it varies from NRs 0 to NRs 10,500. Sampled households use irrigation in their rice field both from public irrigation source (such as canal from river / stream) or from private irrigation source (tube well). But only, 34% of the households have access to public irrigation source. Similarly, 56% of the households have membership in CBOs. Average price of rice seed in the study area is NRs 20.5; however, there is quite variation on it among the households.

Table 4.5 Summary of socio-economic variables included in binary logistic model

Variables	Overall mea	Chitwan	Siraha	Kailali
Age of HHH	41.9±13.64†	49.28±13.48	42.03±12.50	34.34±10.63
Education of HHH	5.20±1.58	6.0±6.61	4.81±5.42	4.08±5.12
Family labor	3.2±8.76	3.6±2.10	3.10±2.32	2.80±0.78
Off-farm income	49,531±67,890	68,640±42,580	48,875±32,256	37,815±20,452
Operational land (ha)	0.78±0.66	0.58±0.45	0.86±0.66	0.91±0.78
Livestock	3.46±1.85	5.06±3.56	1.49±0.48	2.85±1.45
Chemical fertilizer	5,244±1,245	3,594±1,721	5,530±1,493	6,654±3,298
Irrigation	0.34±0.47	0.39±0.49	0.36±0.48	0.26±0.44
CBO	0.56±0.23	0.68±0.24	0.48±0.21	0.51±0.34
Seed price (NRs. kg^{-1})	20.5±16.7	21.3±10.8	20.8±14.21	19.4±8.79

Note: † = Standard deviation, 1 US$ = NRs. 82.96, source: survey, 2011

4.4.4.2 Result of binary logistic model

The significant log likelihood statistic (wald test) shows that the variables chosen for the study fit in the model well (Table 4.6). It means the coefficients of the variables used in the model are significantly different from zero (p = 0.0001). Moreover, the probability of the correct prediction from the model is also high (74.5%). These two

figures show the goodness of fit of the model. The study shows that most of the variables' impact on dependent variable is as hypothesized; however, the influence of age of HHH, family labor and off-farm income is opposite than what was expected. Among the explanatory variables, irrigation, households' membership in CBOs, seed price and location have significant influence on households' decision for the adoption of improved varieties.

The higher motivation of irrigation facility accessed households' for the adoption of improved varieties might be due to their objective of increasing yield with the adoption of these varieties (Nkonya & Norman, 1997; Paudel & Matsuoka, 2008) or cropping intensity (Nkonya & Norman, 1997). However, in addition to canal irrigation (from river) there is potential to use underground water through tube well but less than 5% farmers use tube well; however, the reasons behind it yet to be understood.

In this study, households' membership represents the proxy variable to access extension facility (e.g. agricultural training) from government and NGOs. The significant coefficient and higher marginal effect signifies the importance of CBOs' membership in the adoption of improved rice varieties. As shown in the Table 4.6, the marginal effect of households' membership in CBOs is 0.127 which indicates that households with membership in CBOs have 12.7% higher probability of adopting improved varieties as compared to their counterpart. This finding is consistent with other previous studies (Paudel & Matsuoka, 2008; Tiwari et al., 2008). The reason behind the higher probability of the improved rice varieties adoption by CBOs members might be due to their better linkage with the extension agencies (Department For International Development - DFID, 2010). In the group discussions farmers opined that as a member of CBO they have to participate in the monthly meeting, observation of

new variety demonstration plots. They also discuss about the problems, lessons and potentials about the new crop varieties/technologies in monthly meetings. All these factors might have influence on the adoption decision.

This study also shows that the price of seed plays significant role in household's decision for the adoption of improved rice varieties. It means households experiencing higher seed price are less likely to adopt improved rice varieties and vice versa. Previous studies have shown that farmers normally compare the price of seed with grain of the same commodity in case of self pollinated crops and if the price of seed goes up they tend to use household saved seed (Almekinders, Louwaars & Bruijin, 1994). David (2004) also found same situation in bean in African countries.

Table 4.6 Summary of the results from binary logistic regression

Variables	β	P value	Marginal effect	Odd ratio
Age of HHH	0.031	0.184	0.0041	1.31
Education of HHH	0.112	0.121	0.013	1.06
Labor force at household	-0.043	0.165	0.117	0.46
Annual off-farm income	-0.00031	0.243	0.0001	0.37
Operational land	0.811	0.124	0.140	0.68
Livestock	0.0027	0.943	0.0003	0.41
Chemical fertilizer	0.0002	0.705	0.0002	0.55
Irrigation dummy	0.812	0.03***	0.301	3.45
CBO dummy	0.641	0.079*	0.127	2.85
Price of seed	-0.240	0.0127**	0.014	2.14
Chitwan dummy	0.221	0.014**	0.125	2.35
Constant	-2.184	0.012		
Log likelihood: 85.37**, Number of observations: 107, Percentage correctly predicted: 74.5, Pseudo R^2 square: 0.22				

*, ** and *** indicate significance at 10%, 5% and 1% levels, respectively.

As hypothesized we found that Chitwan district has significant positive influence in the adoption of improved rice varieties. It might be due to other variables which are not

discussed in this study such as road network, communication, and so on.

4.6 Conclusion

This chapter analyzed the types of improved rice varieties grown by farmers, sources of these varieties, and influence of households' socio-economic variables in the adoption of these varieties. Result shows that farmers intend to diversify their varietal portfolio adopting both modern and farmers' varieties, and there is local specificity in adoption of some varieties. Some of the widely grown rice varieties have not been registered in the government system and it is important for their registration to ensure that farmers get extension services from the government agencies. Farmers get seeds of these varieties from various sources such as neighboring farmers, agrovet, CBSPOs and development projects. However, the first two sources are more important than others. Moreover, this study shows that the adoption of improved rice varieties in the study area is mainly explained by access to irrigation facility, households' membership in CBOs, and price of seed. It means combining variety promotional program with irrigation facility would increase the adoption of improved varieties. Moreover, this study recognizes that it is still important to facilitate farmers to be organized in CBOs such as agriculture groups and cooperatives as this activity has positive impact on improved rice varieties adoption. Similarly, this study shows that households experiencing higher price of seed are less likely to adopt the improved varieties. It demands for the development of cost reducing strategies in the production and marketing of seed at local level.

Chapter 5. Efficiency of farmers in rice seed production

5.1 Introduction

Efficiency is the ratio of output and input. Farewell (1957) defined economic efficiency as the ability to produce in given level of output at a lower cost. Economic efficiency is composed of technical efficiency (TE) and allocative efficiency (AE). A farmer is said to be technically efficient if it produces maximum level of output in a given inputs. AE is the extent to which farmers equate marginal value product of factors of production to their price. So, farmers can be economically efficient if they combine inputs in least combination to generate maximum output (technical efficiency) as well as considering least cost to obtain maximum revenue. At this condition farmers are said to be cost effective and this condition leads to profit maximization.

Efficiency in the production can also be improved by introducing technology from developed countries to developing ones. But it has been already recognized that small farmers in the developing countries could not be benefitted from the introduction of resource demanding technologies. Rather they could realize benefit to some extent if they could enhance efficiency by proper allocation of the available resources. This concept yielded a number of past studies in 'efficiency' and these studies have rejected the Schultz's hypothesis (Schultz, 1964) that 'poor people in the developing countries are efficient in utilizing their resources (Kalirajan, 1999; Rahman, 2003; Piya, Kimanami & Yagi, 2012). These studies have identified the variation of efficiency among the farmers from 21 to 93%. In practical sense it is very difficult to compare the efficiency level of farmers from one study to another due to variations in choosing input variables. This necessitates the measurement of efficiency at local level using most commonly used input variables so that appropriate policy recommendation could be

made. This chapter measures AE and TE of rice seed producing households using the most commonly used inputs: source seed, family labor, chemical fertilizer, livestock and operational land, and identifies the socio-economic variables influencing technical efficiency of farmers.

5.2 Analysis of allocative efficiency

5.2.1 Empirical technique

AE was estimated using Cobb Douglas production function with the assumption that rice production dependent on operational land, human labor, seed, fertilizer and livestock. The theoretical model used in the analysis is given in equation 5.1.

$Y = AX_1^{\beta_1}X_2^{\beta_2}\ldots\ldots\ldots\ldots X_n^{\beta_n}\ldots..(5.1)$

Here, Y represents the output, A is the constant, X is input variable, and β is the parameter. The operational model used in the analysis is given in the equation 5.2.

$LnY = \beta_0 + \beta_1 \ln \text{source seed} + \beta_2 \ln \text{labor} + \beta_3 \ln \text{chemical fertilizer} + \beta_4 \ln \text{livestock} + \beta_5 \ln \text{land} + e\ldots.(5.2)$

Ln represents log and e is the error term. The term source seed is the foundation seed (early generation seed) which is produced in the agricultural research station. Labor is the total number of man days required to accomplish the agronomic activities from seed sowing to harvesting and it was measured in LFU^2 as children as well as elderly people were found to be involved in rice seed production. Livestock was used as a proxy variable to represent the animal manure applied in the field and it was estimated as LSU^3. Land is the operational land used for rice seed production.

The above operational model (5.2) was run using OLS technique and estimated the marginal value product (MVP) of the aforementioned production factors and compared it with marginal input cost. Using β coefficient from equation 5.2, marginal product (MP) and average product (AP) was estimated as:

$MP_i = \frac{\partial Y}{\partial X_i} = \beta_i \frac{Y}{X_i}$, and $AP = \frac{Y}{X_i}$

Where, Y is rice output, X_i is the mean of input $_i$, β_i is the estimated coefficient of input $_i$. The value of marginal product of input $_i$ (VMP_i) is calculated by multiplying the marginal physical product (MP_i) with output price (P_y). Thus,

$VMP_i = MP_i * (P_y)$

$AE = \frac{VMP_i}{P_i}$, where P_i = Marginal cost of input $_i$

The decision rule is that if AE of X_i input is >1, the input is underutilized and farmers could increase the profit by increasing the input. Conversely, if AE of X_i is <1, this input is over utilized and farmers have to reduce the input. So, farmers will be at allocative efficient position when $VMP_i = P_i$

5.2.2 Summary of input variables

The summary of output and input variables with respect to their mean and standard deviation is summarized in Table 5.1. Average yield of rice in the study area is 3,839kg ha^{-1} which is 31% higher than that of national average rice yield of Nepal in 2011 (2,916kg ha^{-1}) (FAOSTAT, 2012). There is quite variation in yield of rice across the districts and among the overall sampling households. Farmers in Chitwan get higher yield (4,450kg ha^{-1}), which is 11.7% and 44.2% higher than that of Kailali and Siraha districts, respectively. There is also variation in the application of source seed across the districts. Farmers use lower seed rate than that of national recommendation made by

agricultural research station (50kg ha^{-1}). Similarly, farmers apply major plant nutrients @ 24.7kg N, 20.9kg P and 17kg K ha^{-1} which is quite lower than the national recommendation for irrigated rice in Nepal (100:30:30 :: N : P: K kg ha^{-1}). These nutrients are supplied through different chemical fertilizers such as urea (46% N), Diamonium Phosphate (18% N and 46% P), and Muriate of potash (60% K). On average the amount of fertilizer applied was 153kg ha^{-1} but there is wide variation in its use across the sampled households. There is also quite variation in the labor, and majority of the labor is supplied by family members. Farmers grow rice seed in 0.95ha which represents 77% of their total owned land.

Table 5.1 Summary of the output and input variables

Variable inputs	Overall	Chitwan	Siraha	Kailali
Yield (kg ha^{-1})	3,839±976	4,450±942	3,084±531	3,981±835
Seed (kg ha^{-1})	46.66±6.05	48.11±6.40	44.5±5.51	45.3±0.98
Labor (LFU ha^{-1})	71.60±12.77	61.3±5.08	71.18±12.6	81.28±6.92
Chemical fertilizer (NRs ha^{-1})	153±56	183±104	154±123	122±110
Livestock(LSU $farm^{-1}$)	3.88±12.97	7.7±16.58	1.6±2.58	2.2±1.58
Area under rice seed (ha)	0.952±0.727	0.89±0.71	0.93±0.78	1.0±0.67

5.2.3 Result and discussion

The result shows that livestock, seed and chemical fertilizer have positive direction of influence on rice yield whereas it is negative in case of operational land and labor. However, the significant influence was observed only in case of seed, chemical fertilizer and labor. The elasticity of seed is 0.383% which indicates that 1% increase in seed amount leads to the increase in crop yield by 0.383%. But in case of labor the elasticity figure is negative (-0.258%) which indicates that rice yield would be reduced by 0.2580% with per unit increase labor.

Table 5.2 Elasticity of variable inputs

Variables	Elasticity	Standard deviation	p-value
Seed	0.383**	0.1906	0.046
Labor	-0.258*	0.131	0.052
Chemical fertilizer	0.162***	0.058	0.006
Livestock	0.0377	0.0232	0.106
Operational land	-0.1405	0.0254	0.581
Constant	6.49	1.041	0.324
R^2 = 0.46, *,** and *** indicate significant at 10%, 5% and 1% levels, respectively			

Using the elasticity from Table 5.2, AE was estimated for all the input variables used in the equation 5.2. In this case, price of operational land is land rent value (NRs ha^{-1}) for the rice growing season. In case of livestock, the value of manure was estimated considering the figure that one adult buffalo (1LSU) gives 60kg nitrogen in a year and if farmers apply two times in a year, the rice field gets 30kg. So, the cost of animal manure was estimated considering its value with the price of urea. Labor price was estimated as average wage considering both male and female laborers, and unit price (NRs kg^{-1}) of chemical fertilizer was calculated considering both quantity and price of fertilizers. The result shows that land and labor have been over utilized, but animal manure, chemical fertilizer and seed have been underutilized (Table 5.3).

Table 5.3 Estimates of allocative efficiency

Variables	Coeffi cient	Average product	Marginal product	Output price	Marginal value product	Input price	Allocative efficiency
Seed	0.383	46.66	68.16	18.02	1,228.24	65	18.89
Labor	-0.258	55.45	-14.31	18.02	-257.79	325	-0.793
Chemical fertilizer	0.162	25.09	4.06	18.02	73.24	64	1.144
Livestock	0.137	2919	399.9	18.02	7,206.2	2,000	3.61
Operational land	-0.014	8036	-112.50	18.02	-2027.32	4,500	-0.450

It means the farmers could maximize the profit from rice seed production by increasing these three inputs.

5.3 Estimation of technical efficiency

5.3.1 Empirical technique

Stochastic Frontier Production Model was used to analyze TE. In this model, a farmer is said to be technically efficient if its output falls on the frontier output (maximum possible output) in the given set of inputs (Battese & Coelli, 1995). There two types of parametric frontier production functions used in the literature in measuring the TE of farmers: deterministic and stochastic; however, the latter is considered more efficient than previous as it has two error terms, one of which separates the random noise effect from the total residual (also called composed error) and gives consistent estimate for efficiency/inefficiency (Battese & Coelli, 1995). The theoretical idea of stochastic frontier production is that no one can produce output beyond the theoretically possible limit. The measurement of efficiency/inefficiency is thus possible how agents are far away from the limit. This model was originally proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) and its functional form is expressed as:

$Y_i = f(x_i, \beta) \exp(v_i - u_i)$…….(5.3)

Here, Y_i is the quantity of production of ith farm with i ranging from 1, 2……..n. x_i is the explanatory variable input, β is the vector of parameters to be estimated, v_i represents the two-sided error term accounting for random variation in output due to factors outside the control of farmers such as measurement errors, diseases and pests infestation in the field, natural calamities, etc. Another term u_i represents the error

term associated with farm level technical inefficiency, and this inefficiency might occur due to variation in socio-economic variables such as education, extension, infrastructure, and so on. Here, v_i is assumed to be distributed independent of each u_i and both errors are supposed to be uncorrelated with explanatory variables (x_i). The noise component v_i is assumed to have zero mean and constant variance (σ_v^2) and distributed normally; whereas inefficiency component u_i is assumed to have zero mean with variance (σ_u^2) and distributed half normally. As proposed by Aigner, Lovell and Schmidt (1977), the log likelihood function for the half normal model is as given in equation 5.4. This likelihood function estimates whether the variation among the observations is due to inefficiency. From the likelihood function, we get σ^2 and λ^2, where $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $\lambda^2 = \sigma_u^2 | \sigma^2$. If $\lambda = 0$ there is no inefficiency effect and the variation in the data just due to random noise, and higher the value of λ reflects more inefficiency effect explained by the model

$$\ln L(Y_i|\beta, \sigma\lambda) = -\frac{1}{2}\ln(\pi\sigma^2) + \sum_{i=1}^{n} \ln \phi \left\{\frac{-\varepsilon_i\lambda}{\sigma}\right\} - \frac{1}{2\sigma^2} \sum_{i=1}^{n} \varepsilon_i^2 \quad \text{.....(5.4),}$$

Where, Y_i is the vector of log outputs, $\varepsilon_i = v_i - u_i = \ln Y_i - x_i\beta$ is composite error term and $\phi(x_i)$ is a cumulative distribution function of the standard normal variable evaluated at x_i. The TE of farmer $_i$ in the context of stochastic production function can be expressed as:

$$TE_i = Y_i / Y_i^* = f(x_i; \beta) \exp(v_i - u_i) / f(x_i; \beta) \exp(v_i) = \exp(-u_i) \quad \text{.....(5.5),}$$

Where, Y_i* is the maximum possible output; Y_i, x_i, β, v_i and u_i are as explained earlier. Here, TE_i represent TE and it is the ratio of farm output (crop yield in this research) relative to the maximum output that can be produced in the same level of input vectors. The value of TE_i ranges from 0 to 1. If $TE_i = 1$, Y_i achieves the maximum value of $f(x_i; \beta) \exp(v_i)$, and $TE_i < 1$ represents the shortfall of production

from the maximum possible production level in environment characterized by stochastic elements which vary across the farmers.

In the first stage, TE was computed from stochastic frontier production model (Cobb Douglas functional form) using the same set of explanatory variables used to estimate the AE in equation 5.2. In the second step, TE (as dependent variable) was regressed against socio-economic variables of farmers/farm using OLS as this technique can be applied if the efficiency values are higher than zero and less than 1. Previous studies have also adopted two stage procedures to analyze the efficiency of farmers in the developing countries (Kalirajan, 1999; Sharma, Leung & Zaleski, 1999; Piya, Kiminami & Yagi, 2012).

After estimating stochastic frontier production function (5.2), the TE was predicted using the formula given in equation (5.5) and TE score was regressed against socio-economic variables (5.6) to find out their impact on TE.

$TE_i = \delta_0 + \delta_1$ ln age of HHH $+\delta_2$ ln education of HHH $+\delta_3$ training dummy $+ \delta_4$ ln active labor force $+ \delta_5$ ln irrigation cost $+ \delta_6$ ln land rent $+ \delta_7$ ln experience $+ \delta_8$ ln off-farm income $+ \delta_9$ Chitwan $+ \omega_i$……(5.6)

Where, δ represents the parameters associated with socio-economic variables, and ω_i is the error term. The sign of socio-economic variables and their description has been presented in Table 5.4. Out of these variables, the impact of age and education of HHH were hypothesized to have positive (Ali & Flinn, 1989; Rahman, 2003). Training and experience in seed production are capacity enhancement variables, and these variables were supposed to have positive influence on technical efficiency (Rahman, 2003). Similarly, the influence of irrigation cost was hypothesized to have negative on TE. The influence of land rent was hypothesized positive (Ghaderzadeh & Rahimi, 2005). Since

majority of labor force in rural areas is supplied by family members of farmers, which makes it easy to access labor when required and easy accessibility of labor might positively contribute in the production. So, family labor at household was hypothesized to have positive influence on TE. Similarly, household income from off-farm source was also assumed positive contribution on TE, as farmers could accomplish agricultural activities on time if they have access to off-farm resources (Ali & Flin, 1989; Wang, Cramer & Wailes, 1996; Rahman, 2003). We have used Chitwan as dummy variable in the analysis considering that this district might have positive influence on TE due to better infrastructure and extension facility.

Before running stochastic frontier production model and OLS, data were validated for multicollinearity, heteroskedasticity and endogeneity using VIF test, Breusch-Pagan/Cook-Weisberg test, and Hausman method, respectively. The VIF test shows the value <10 indicating no problem of multicollinearity (Pindyck & Rubinfield, 1981). Similarly, Breusch-Pagan/Cook-Weisberg test also indicate that there is no problem for heteroskedasticity as the hypothesis of constant variances of the residuals was accepted ($p>0.3$). While running OLS regression, some variables such as land rent, irrigation cost and off-farm income were checked for their possibility of endogeneity with the level of TE. But Hausman test did not show such problem in these variables, so used simple OLS instead of estimating instrumental variables.

Table 5.4 Socio-economic variables used in the model

Variable	Description	Coefficient	Expected sign
Age of HHH	Age of household head in years	δ_1	+/-
Education of HHH	Formal schooling years of HHH in years	δ_2	+/-
Training	If household attended agricultural training = 1, and 0 for otherwise	δ_3	+
Labor	LFU[2] available at households	δ_4	+
Irrigation cost[4]	NRs ha^{-1} in the rice growing cropping season	δ_5	-
Land rent[5]	NRs ha^{-1}/cropping season	δ_6	+
Experience	Years of household's participating in seed marketing	δ_7	+
Off-farm income	Amount of cash money household's receive from members in a year (NRs $year^{-1}$)	δ_8	+
Chitwan	If household from Chitwan = 1, and 0 for otherwise	δ_9	+

5.3.2 Summary of explanatory variables

The average age of HHH is 46.8 years but it varies from 16 years to 78 years. In case of dummy variable, the mean value shows the percentage of farmers adopting those practices. For example, in case of training, the mean value is 0.78 which indicates that 78% of the households have got training about seed production. There is also quite variation in land rent ranging from NRs 3,000ha^{-1} to NRs 9,000ha^{-1} per cropping season (i.e. 6 months) in the study area, and this figure is also higher in Chitwan as compared to other two districts.

Table 5.5 Summary of the explanatory variables

Variable inputs	Overall	Chitwan	Siraha	Kailali
Age of HHH	46.8±11.43	49.8±12.05	46.1±10.9	44.6±10.8
Education of HHH	7.96±4.02	10.6±2.97	6.8±4.1	6.4±3.4
Training	0.78±0.41	0.81±0.39	0.68±0.46	0.85±0.36
Active labor force	3.4±0.37	2.21±1.35	4.12±1.25	4.23±2.04
Irrigation cost	1,863±1135	1,822±1369	2,267±1169	1,500±605
Land rent	6,145±1,827	8,310±872	4,125±655	6,000±2,540
Experience	4.37±0.97	5.8±0.35	4.2±0.57	4.1±0.52
Off-farm income	42,998±52,622	53,990±14,566	43,510±16,540	25,950±16,452

Note: SD = Standard deviation, 1 US$ = NRs. 82.96, Source: survey, 2011

5.3.3 Findings from stochastic frontier production model

Table 5.6 presents the findings from stochastic frontier production model. The significant loglikelihood (wald test) signifies that variables chosen fit in the model well. Moreover, the likelihood ratio test for the "absence of inefficiency in the model" is rejected at p = 0.002 and this indicates that inefficiency effect explained in the model is higher than random noise. Marginal effect of input variables on rice yield was also estimated because the stochastic frontier model was run through maximum likelihood method, and coefficients of input variables do not represent their average impact on dependent variable. All the input variables except labor and land have positive response on yield. The marginal effect of labor is -0.11indicating that 1% increase in LFU leads to decrease in rice yield by 0.11%. The impact of chemical fertilizer and livestock is also positive. The significant impact of livestock on rice yield indicates the importance of livestock manure in rice yield.

Table 5.6 Effect of explanatory variables on crop yield

Variables	Coefficient± SD	P-value	Marginal effect
Seed	0.335±0.194	0.75	0.158
Labor	-0.221±0.120	0.017**	-0.111
Chemical fertilizer	0.089±0.051	0.081*	0.089
Livestock	0.032±0.0.016	0.057*	0.020
Operational land	-0.018±0.024	1.90	-0.019
Constant	7.40±1.11	0.124	
Log likelihood: -110.38**, σ^2 = 0.143, λ = 2.35, Likelihood ratio = 46.58***, n = 121, *,**,*** indicate significant at 10%, 5% and 1% level, respectively			

**, ** indicate significant 5% and 10% level of significance, respectively

5.3.4 Technical efficiency of farmers

The result shows that there is 81% efficiency of farmers in rice seed production and it varies from 36.7% to 95.2%, meaning that farmers could improve efficiency in rice seed production by 19%. The efficiency level also differs among the districts. Average efficiency of farmers in Chitwan, Siraha and Kailali is 85.1%, 75.8% and 81.8%, respectively. Previous studies have also identified wide range of efficiency among the farmers. For example, Kyi and Oppen (1999) found average efficiency of farmers 88% ranging from 39% to 93% in irrigated rice of Myanmar. Similarly, Idiong (2007) found efficiency of Nigerian rice farmers as 77% ranging from 48% to 99%. The recent study by Piya, Kiminami and Yagi (2012) found the efficiency of Nepalese rice growers 74% ranging from 35% to 100%.

5.4 Impact of socio-economic variables on technical efficiency

A total of nine socio-economic variables were tested for their impact on TE, and the result shows that direction of impact of most of the variables is as per the hypothesis except for family labor, and age of HHH (Table 5.7). However, education of HHH, households' experience on seed marketing, land rent and location have significant

positive influence on TE. We also estimated yield loss of the variables having significant influence on TE. The significant positive response of education of HHH on TE indicates that efficiency of the farmers would be further increased with the current education level (7.8 years). In the study area still 35.6% of HHH are below primary education level (one to five years of formal schooling), and this category of households experience less yield (16.6%), fetch higher yield loss (17.6%), and operate in the lower efficiency level (8.7%) than those having higher education. Previous studies have also shown the positive response of education on TE of farmers (Idiong, 2007; Piya, Kiminami & Yagi, 2012). The better performance of higher educated HHH might be due to their better analytical capability and extension contact (Battese & Coelli, 1995). The study also shows that 1% increases in land rent leads to 0.045% increase in TE. Land rent represents the land quality, and to compare the level of land quality with efficiency.

Table 5.7 Influence of socio-economic variables on technical efficiency

Variables	Coefficient (± Standard deviation)	P-value
Age of HHH	-0.0325 (0.049)	0.251
Education of HHH	0.0042 (0.002)	0.06***
Family labor	-0.014 (0.16)	0.876
Training	0.052 (0.045)	0.264
Irrigation cost	-0.008 (0.09)	0.968
Land rent	0.045 (0.042)	0.005***
Experience	0.063 (0.062)	0.0112**
Off-farm income	0.0545 (0.0041)	0.0683
Chitwan	0.034 (0.028)	0.023**
Constant	0.023 (0.041)	0.004***
Number of observations: 121, R^2: 56%, Adjusted R^2 = 52%, **,*** indicate significant at 5% level and 1% level, respectively. Figures inside the parenthesis are standard deviation		

Households are divided into good land quality households (>NRs. 7,000/season/ha) and poor land quality households (<NRs. 7,000/season/ha). It was found that the

households under the former category got higher yield (20%), experienced less production loss (21%), and these farmers operate in higher TE level (8.78%) as compared to the counterpart.

The study also shows the significant positive influence of household's experience about seed production on TE. As shown in the Table 5.7, 1% increment in years of experience leads to increase efficiency of farmers by 0.063%. Households with over three years experience in seed production realized 3.6% higher efficiency as compared to those having less experience (p = 0.047). Other studies have also shown the positive link between farmers' experience and level of technical efficiency (Kyi & Open, 1999; Idiong, 2007). The reason behind the higher efficiency of experienced farmers might be due to their better skills in managing resources than less experienced farmers.

Table 5.8 Observed yield, yield loss and technical efficiency of significant variables

Variables	n	Observed yield	Yield loss	Technical efficiency (%)
Education of HHH				
Primary (≤ years)	36	3453	1,203	0.73
Above (>5 years)	85	4,027	991	0.79
p-value		0.002***	0.005***	0.001***
Land rent (NRs for 6 months)				
≤7000	50	3,655	1,108	0.758
> 7000	71	4571	873	0.831
p-value		0.001***	0.008***	0.001***
Experience (years)				
≤3	45	3,648	1,263	0.7568
>3	76	3,904	1,016	0.783
p-value		0.006***	0.0001***	0.0008***

Note: *,**,*** indicate difference between categories by 10%, 5% and 1% respectively. Production loss = Maximum possible production – Observed production, and maximum possible production = Observed production / TE

5.5 Conclusion

This chapter analyzed the AE and TE of farmers in using their major inputs (seed, labor, fertilizer, operational land and livestock). The findings from AE shows that farmers are not allocatively efficient in the study area where labor and land are over utilized and other three variables (livestock, seed and chemical fertilizers) are underutilized. It means farmers could increase rice yield by proper allocation of these variables. Similarly, farmers are 81% technically efficient in the utilization of these inputs and there is wide variability among the farmers in TE which is mainly explained by education of HHH, land quality and household's experience in seed production. Since the provision of formal education to HHH might not be practicable considering their age, field demonstrations would be useful to enhance their efficiency level. More research is needed to identify the appropriate land quality management measures. Experience in seed production shows the importance of market orientation in TE.

Chapter 6. Soil conservation practices in rice seed production

6.1 Introduction

It is clear from the previous chapter that land quality has positive role in enhancing farmers' TE in rice seed production. It means there is a potential to enhance economic benefit at household level by improving land quality. The land quality also provides basis for the continuation of the current benefit seed producers get from rice seed production in the future. Soil Conservation practices (SCPs) have been found to address land quality issue, especially by improving water use efficiency and enhancing soil organic matter content. In spite of the great roles of SCPs in enhancing rice crop yield as well as providing basis for sustaining the rice yield, it is important to explore how farmers select these practices in rice seed production from policy perspective. This chapter analyzes the impact of socio-economic factors for the adoption of different soil conservation practices.

6.2 Major soil conservation practices used in rice-based system

Farmers adopt different SCPs considering their cropping system as a whole. For example, animal manure is applied only once in a year during rice planting time in 30% of the cases whereas only in wheat in 20% of the cases and half of the respondents apply animal manure two times in a year. Farmers believe that even if they apply manure in one crop the remaining nutrient after the harvest of that crop would be useful for the succeeding crop. It was found that farmers use six types of SCPs in the rice based system (Table 6.1). These practices are broadly classified into two categories: water saving (SRI, ZT), and soil organic matter enhancement (animal manure, compost, botanical pesticide and green manure).

Table 6.1 Summary of soil conservation practices adopted in rice-based system

Categories	Overall	Chitwan	Siraha	Kailali	P-value†
Zero tillage					
Adopters	84 (46.67)	17 (28.33)	30 (50)	37 (61.67)	0.001
Non-adopters	96 (53.33)	43 (71.67)	30 (50)	23 (38.33)	
Compost					
Adopters	36 (20)	6 (10)	3 (5)	27 (45)	0.000
Non-adopters	144 (80)	54 (90)	57 (95)	33 (55)	
System of rice intensification (SRI)					
Adopters	22 (12.22)	3 (5)	4 (6.67)	15 (25)	0.001
Non-adopters	158 (87.78)	57 (95)	56 (93.33)	45 (75)	
Botanical pesticide					
Adopters	50 (27.78)	20 (33.33)	5 (6.67)	25 (41.67)	0.000
Non-adopters	130 (72.22)	40 (66.67)	55 (91.67)	35 (58.33)	
Green manure					
Adopters	109 (60.56)	31 (51.67)	32 (53.33)	46 (76.67)	0.007
Non-adopters	71 (39.44)	29 (48.33)	28 (46.67)	14 (23.33)	

Note: Figures in the parenthesis indicate percentage. † =χ^2 test, Source: Survey, 2011

For example, in addition to saving water, surface seeding also contributes in enhancing the level of organic matter in soil by reducing the rate of organic matter decomposition in soil. Animal manure is the most common source of SCPs adopted by farmers across the district. However, it is higher in Chitwan as compared to other two districts. Among all SCPs, ZT is practiced targeting in wheat whereas the other practices for rice. As given in Table 6.1, 46.67% of the households adopt ZT, and the proportion of households adopting this practice is higher in Kailali as compared to Chitwan or Siraha.

Overall, 50.56% of the households have adopted green manure (crops grown as green biomass and incorporate in rice field during final land preparation time), and the category of households adopting this practice is also higher in Kailali as compared to other districts. The green manure crops grown by farmers are maize (*Zea mays*),

Dhaincha (*Sesbania* spp) and Til (*Sesamum indicum*) in Chitwan, whereas it is Mungbean (*Vigna mungo*) in Siraha and Kailali. Very limited households (20%) were found to adopt compost, and Kailai district has the majority of the adopters. Famers prepare compost using dried leaves collected from forest and or weed/crop residues, and effective micro-organism/slurry is added to accelerate the process of decomposition. There is also significant difference between the distribution of adopters and non-adopters of compost across the districts. Only 12.22% of the households adopt SRI practice (in rice), and the proportion of SRI adopters was also higher in Kailali as compared to other two districts. Similarly, only 27% of the households use botanical pesticides to control pests/diseases in rice. This does not mean that the remaining households use chemical pesticides, as only 3% households were found to use chemical pesticide in rice for weed control. The reasons behind the higher proportion of adopters in Kailali might be due to the impact of development project activities as most of the respondents (60%) of this district were associated with research into use program implemented by NGOs.

6.3 Households' behaviour in adopting soil conservation practices

6.3.1 Conceptual framework

Previous section shows that farmers adopt different SCPs using resources from their farm and forest. Also, it is clear from the literature that SCPs such as ZT, SS (Granatstein et al 1987; Ladha et al., 2003), green manure (Dahal et al., 1993; Devkota et al., 2006; Pandey, Shah & Becker, 2008), system of rice intensification – SRI (Upreti, 2008), botanical pesticides, animal manure and compost (Lal et al., 1998) give economic, social and environmental benefits to the farmers. It could be argued that farmers adopt these practices based on the benefits they realized from these practices

but it is difficult to capture the trade-off between different benefits received from these practices. To address this complexity the adoption of SCPs was analyzed from the perspective that households could realize economic benefits/incentives while adopting the practices. The consideration of economic benefits might be more appropriate for small farmers because the environmental and social benefits to be realized by this category of farmers are time and risk questions and not easily visible (Lee, 1980).

This does not mean that measuring economic benefits from SCPs is simple and direct. For example, farmers could realize different economic benefits from the same SCP (e.g. water saving, reduction of cultivation cost and yield increase from surface seeding) and how farmers allocate their emphasis across these benefits is complex. Also, farmers as a profit maximizer tend to innovate technologies or process in utilizing the existing SCPs continuously. This makes it more difficult to put the long term benefits to be realized by from SCPs into utility functions. Moreover, the criteria set by researchers and policy makers about economic benefits from SCPs might be different from those of farmers. In this context, adoption studies from the assumption that farmers adopt the practices by perceiving potential costs and benefits from available SCPs in the whole cropping system could be more logical (Kassie et al., 2012; Tripathi et al., 2006). According to adoption and diffusion theory (Rogors, 1995) perception is a step in the technology adoption process. The perception is influenced by various demographic (age, education, labor, attitude), biophysical (disease, pest, climate stress, field characteristics), economic, social and institutional (land tenure, linkage) factors (Shiekh et al., 2002; Erenstein & Laxmi, 2008; Kassie et al., 2012).

6.3.2 Empirical model

6.3.2.1Theoretical concept

This study used multivariate probit (MVP) model to analyze how explanatory (socio-economic) variables influence households' decision to adopt different SCPs. In this model, dependent variable is multivariate, binary and correlated. This model assumes that given a set of explanatory variables the multivariate response is an indicator of the event that some unobserved latent variables (Z), assumed to arise from the multivariate normal (Gaussian) distribution, and falls within a certain interval (Tabet, 2007). As discussed in the conceptual framework, farmers could integrate different SCPs to address their economic goal considering the cropping system perspective. This justifies the modeling of SCPs simultaneously using MVP model rather than Univariate Probit Model. Though Multinomial Logit is also found using to analyze the similar data in the literature but MVP is more suited for correlated binary dependent variables which are not mutually exclusive (Shiekh et al., 2002; Young et al., 2009). Also, the MVP model relaxes the independence of the irrelevant alternatives property assumed by logit model (Tabet, 2007). This model was also used by previous researchers (Cappelari and Jenkins, 2003; Kassie et al., 2012) to analyze the impacts of socio-economic factors in households' decision for the adoption of SCPs. Theoretically, the MVP model is presented in equation 6.1 and 6.2.

$$Y_{ij} = \begin{pmatrix} 1\ if Z_{ij.}>0 \\ 0\ if\ no \end{pmatrix} \ldots\ldots\ldots\ldots\ldots\ldots (6.1)$$

$$Z_{ij} = x_i\beta + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots (6.2)$$

Where, Y_{ij} is the binary dependent variable taking value 0 or 1 on the i^{th} households and jth options in dependent variable. Similarly, Z is the vector of latent variable, β is a matrix of the regression coefficient associated with explanatory variables (X).

Moreover, ε is a vector of residual error term distributed as multivariate normal distribution with zero mean and unitary variance; $\varepsilon_i \sim N(0,\Sigma)$, where Σ is the variance-covariance matrix having value 1 on the leading diagonal. The off diagonal element in the correlation matrix, $\rho_{kj} = \rho_{jk}$ represents the unobserved correlation between the stochastic elements of the jth and kth items. The relationship between Z_{ij} and ρ_{kj} is given by the likelihood of the observed data that can be obtained by integrating over the latent variables Z (equation 6.3).

$$p(Y_{ij} = 1/x_i,\beta,\Sigma) = \int A_{ij},\ldots\ldots,\int A_{i1}\emptyset_r(Z_{ij}/X_i, \beta,\Sigma)dZ_{ij} \quad \ldots\ldots\ldots\ldots\ldots\ldots(6.3)$$

Where A_{ij} is the interval (0,∞) if Y_{ij} = 1, and the interval (-∞, 0) otherwise.

Similarly, $\emptyset_j(Z_{ij}/X_i, \beta,p_{ij})$ is the probability density function of the standard normal distribution. The study uses the simulated maximum likelihood (SML) method using Geweke Hajavassiou-Keane (GHK) simulator in STATA developed by Cappelari and Jenkins (2003) to estimate the MVP model. According to Cappelari and Jenkins (2003), the SML simulator tends to be consistent once the number of observations and number of draws tend to be infinitive. In general, the number of draws is considered square root of the sample size if the latter is thousand and above. However, for small sample size the number of draws should be increased from its default number (5) to enhance the precision of the coefficient. So, the number of draw was set as 100 while estimating the model.

As per the regression rule, diagnostic tests were carried out to check the heteroscedasticity and multicollinearity problems n the data. For this, the same set of socio-economic variables was regressed against the choice dependent variables individually using OLS technique. VIF test was carried out to check multicollinearity among the variables. The VIF value for the dependent variables across the three

equations was below 10 which indicated that multicollinearity problem did not exist in the data. Similarly, Breusch-Pagan/Cook-Weisberg test showed that the selected data set was free from heteroscedasticity as the null hypothesis of constant variances of the residuals was not rejected ($p > 0.4$) in all the tested equations.

6.3.2.2 Variables and operational model

The study shows that six SCPs: compost, ZT, green manure, system of rice intensification (SRI) and botanical pesticides were adopted by the farmers. Among these practices, ZT was adopted in rice whereas all other practices in rice. Since SRI consists of package of practices such as planting 10-14 days old seedling, maintaining wider spacing than conventional method while seedling transplanting, provision of major nutrients from organic matter, and drainage (Upreti, 2008). It was found that none of the seed producers were using full package of practices of SRI. So, farmers transplanting single seedling in combination with any one of the above practices were considered adopters of SRI. The animal manure was dropped from the analysis as all the farmers were found to adopt this practice. Then, the remaining five variables were used as dependent variables in the model. Again, the number of farmers adopting botanical pesticides, SRI, and compost were limited (Table 6.1). So, these three variables were combined under the name 'improved practice', and finally this variable and other two variables (green manure and ZT) were used as dependent variables in the model. The operational model used in this paper is given in equation 6.4.

(**Zero tillage** = β_{a0}+ β_{a1} age + β_{a2} education + β_{a3} family labor + β_{a4} irrigation + β_{a5} livestock + β_{a6} training + β_{a7} operational land + β_{a8} ln fertilizer cost + β_{a9} on − farm income + β_{a10} diversification index + ε_a) (**Green manure** = β_{b0} + β_{b1} age + β_{b2} education + β_{b3} family labor + β_{b4} irrigation + β_{b5} livestock +

β_{b6} training + β_{b7} operational land + β_{b8} ln fertilizer cost + β_{b9} on-farm income + β_{b10} diversification index + ε_b) (**Improved practice** = β_{c0} + β_{c1} age + β_{c2} education + β_{c3} family labor +β_{c4} irrigation + β_{c5} livestock + β_{c6} training + β_{c7} operational land + β_{c8} ln fertilizer cost + β_{c9} on-farm income + β_{c10} diversification index + ε_c)……..(6.4)

Here, Ln = log; β_a, β_b and β_c are the vectors of the coefficients of explanatory variables related to ZT, green manure and improved practices, respectively. The explanatory variables used in the study were chosen on the basis of economic theory and previous studies. Literature shows that demographic, economic and institutional variables might influence households' decision for adopting SCPs but the hypothesized relation of the variables with adoption choices might be specific to local context (Ereistein, 2009; Kassie et al., 2012). For example, land tenure was used as an component of explanatory variable to understand its influence in households' decision making for adopting SCPs in food production in Tanjania but we found that seed production was limited only to households' own land.

The summary of explanatory variables and their hypothesized relation with the dependent variables is given in Table 6.2. The demographic variables included in the study are age and education of HHH, and family labor. Age and education were hypothesized to have positive influence on the adoption of all dependent variables as they contribute to human capital (Ervin & Ervin, 1982), whereas, the influence of family labor on ZT was assumed negative as this technique saves labor and allows farmers for timely wheat sowing. Also, it might contribute on rice yield by improving the soil organic matter (Tripathi et al., 2006).

The economic variables included in the model are operational land, irrigation facility, livestock holding, fertilizer cost, proportion of on-farm income to total household income, and variety diversification index (VDI). As shown in Table 6.2, operational land was hypothesized to have positive influence across the dependent variables as this category of households has higher motivation to maximize the crop production utilizing the resources (Shiekh et al., 2002). Households' access to irrigation facility was considered negative in case of ZT because farmers normally use ZT in the rain-fed area utilizing the residual moisture retained in the soil from monsoon season (Tripathi et al., 2006). But irrigation's impact was hypothesized positive in 'green manure' and 'improved practice' as irrigation might influence households' for adopting these practices. The influence of livestock was assumed neutral on ZT and improved practice, but it was hypothesized negative in case of green manure. This is because green manure releases nutrients in soil quickly and also these manures are rich in nitrogen, and so farmers with higher livestock holding might be less likely to adopt green manure as they could apply most of the nutrients from livestock manure. Similarly, the influence of fertilizer cost was assumed neutral to ZT but negative in green manure and improved practice. The proportion of household's annual on-farm income to annual total cash income was hypothesized to have positive influence across the dependent variables because farmers having higher proportion of on-farm income might be more conscious towards adopting SCPs in relation to the economic benefit they intend to get from farming.

Diversification of crop varieties is the common measure to address risks among smallholder farmers. It was hypothesized that higher risk averters are more likely to adopt SCPs because SCPs also contribute in enhancing the diversity of soil microbes

(Belknap & Saupe, 1988). The VDI was calculated as a ratio of number of rice varieties grown by household to the total number of rice varieties grown by respective CBSPOs because rice is the major crop in seed production (which contributes 80% of the total seed production). The institutional variable considered in this study is households' linkage with government and non-government organizations. These organizations provide training to the seed growers in various dimensions of seed production including SCPs. So, households' attending agricultural training was used as a proxy variable to represent their linkage with these organizations. It was assumed that trained households are more likely to adopt SCPs due to knowledge and experience they get from training.

6.3.3 Results and discussion

6.3.3.1 Summary statistics

As discussed previously, adopters in SRI, compost and botanical pesticides were grouped under 'improved practice'. The summary statistics show that overall, 44% of households adopted improved practices, and the proportion of adopters is higher in Kailali (76%) as compared to Chitwan (40%) and Siraha (16%).Table 6.3 presents the summary of explanatory variables used in the analysis with respect to their mean and standard deviation. In case of dummy variables, the mean value indicates the percentage of households adopting the practices.

For example, the mean value for irrigation facility is 0.55 meaning that 55% of the households have access to pubic irrigation source. Farmers primarily use chemical fertilizer in rice and its use is quite lower than the national recommendation in rice (100:30:30kg :: N : P: K kg ha^{-1}) (Tripathi et al., 2006). Overall, farmers apply major plant nutrients @ 24.7kg N, 20.9kg P and 17kg K ha^{-1}. These nutrients are supplied

through different chemical fertilizers such as urea (46% N), Diamonium Phosphate (18% N and 46% P), and Muriate of Potash (60% K).

Table 6.2 Summary of explanatory variables used in the model

Variables	Definition	Mean± SD	Expected sign
Age of HHH	Age of household head (years)	46.83±11.43	+ ve to ZT & -ve to others
Education of HHH	Formal schooling attended by HHH (years)	7.96±4.02	+ve to all
Family labor	Labor force unit (LFU)[2]	3.41±0.37	- ve to ZT & +ve to others
Operational land	Total operational land of households (ha)	1.15±0.90	+ve to all
Irrigation	1 = access to canal irrigation , 0 for otherwise	0.55±0.49	Same as family labor
Livestock	Livestock Standard Unit (LSU)[3]	3.89±4.88	-ve to green manure & +ve/-ve to others
Fertilizer cost	Chemical fertilizers households (NRs/ha/year)	6,649.1±4,850.4	+ve/-ve to ZT & -ve to others
On-farm income	% of annual on-farm income/total household income	0.40 ±0.25	+ve to all
Diversification index	Variety diversification index in rice	0.19±0.07	+ve to all
Training	1 = Attended agriculture training, and 0 for otherwise	0.783±0.41	+ve to all

Note: ZT = Zero-tillage, SD = Standard deviation, 1 US$ = NRs 82

6.3.3.2 Results from multivariate probit model

The study shows that the direction of impact of most of the socio-economic variables is as per the expectation with few exceptions (Table 6.3). The significant likelihood function as given by wald test indicate that the variables chosen in the study fit in the model well. Also, the likelihood ratio test rejected the hypothesis of the

independence of error term of individual equation (p = 0.0001). Households with higher family labor are significantly less likely to adopt ZT practice. This might be due to the ability of higher family labor having households to plant wheat on time as wheat planting after the end of November could decrease the crop yield (Aslam et al., 1993).

Moreover, ZT adopters realized 3.1% higher rice yield than the control group. This might be due to higher organic matter in ZT adopted fields. Granatstein et al. (1987) found 0.2% increment in organic matter after the adoption of ZT practice continuously for 10 years in wheat. Shah et al. (2011) also found higher soil organic matter in ZT adopted fields. Similarly, the study shows that households with higher operational holdings are significantly more likely to adopt ZT practice (Shiekh et al., 2002).

Table 6.3 Impact of socio-economic variables on the adoption of soil conservation practices

Variables	Zero Tillage (1)	Green manure (2)	Improved practices (3)
Age of HHH	0.007(0.411)	-0.010(0.242)	0.0019(0.830)
Education of HHH	-0.010(0.695)	-0.010(0.706)	-0.022(0.423)
Family labor	-0.015(0.0675)*	-0.014(0.680)	-0.014(0.679)
Operational land	0.380(0.008)***	0.170(0.206)	0.025(0.835)
Irrigation	-0.073(0.735)	0.394(0.033)**	0.540(0.013)**
Livestock	0.001(0.850)	-0.008(0.274)	0.003(0.638)
Fertilizer cost	0.001(0.204)	-0.001(0.108)	-0.001(0.030)**
On-farm income	0.001(0.337)	0.004(0.745)	0.002(0.546)
Diversification index	2.933(0.055)**	2.21(0.745)	3.548(0.024)**
Training	0.005(0.984)	0.161(0.500)	0.477(0.064)*
Constant	-1.525(0.021)**	-0.169(0.155)	-1.704(0.011)**
ρ_{21} = 0.496 (0.001)***, ρ_{21} = 0.321 (0.005)***, ρ_{21} = 0.302 (0.006)***, n = 180, Wald test (Chi 30): 49.35, p = 0.0014; Log likelihood = -318; Log likelihood ratio test; $\rho_{21} = \rho_{21} = \rho_{21} = 0$, Chi-square = 27.72, p = 0.0001, Number of draws = 100; figures in the parenthesis indicate probability values; *,** and *** means significance at 10%, 5% and 1% , respectively.			

Moreover, households with higher VDI are also significantly more likely to adopt this practice. It shows that risk aversion characteristic could positively motivate farmers to adopt ZT. Farmers argued that the most important risk they have reduced from adopting ZT is escape of crop from terminal drought as it allows them to sow wheat seed on time i. e. within November. Belknap & Saupe (1988) also noted that planting of wheat after first week of December significantly decreases the wheat yield. Moreover, ZT adopters have 5.39% higher TE as compared to their counterparts which might be due to better land quality in ZT adopted field. In spite of this, only 10% of the farmers are aware that ZT increases soil quality which might be due to poor education of HHH (7.6 years), and slow build-up of organic matter in ZT adopted field (Granatstein et al., 1987; Shah et al., 2011).

Similarly, green manure adopters received 24.8% higher yield in rice as compared to the control group. This practice also plays complementary role in enhancing the productivity of ZT and improved practice (Table 6.4) which might be due to the improvement of soil quality.

Table 6.4 Rice yield and technical efficiency under different soil conservation practices

Conservation practices	**Rice (kg ha^{-1})**		**Technical efficiency (%)**	
	Mean± SE	% Over control	Mean± SE	% Over control
Zero tillage (ZT)	3,420±378	3.1	72.3±3.45	5.39
Green manure (GM)	4,140±228	24.8	79.3±8.24	15.59
Improved practice (IP)	3,745±237	12.9	77.9±14.23	13.55
ZT + GM	3,702±200	11.6	80±17.52	16.61
ZT + IP	3,748±208	13.02	74.06±13.24	7.95
GM + IP	4,036±196	21.7	83.4±2.57	21.57
ZT+GM+IP	4,322±147	30.3	82.5±4.98	20.26
Control	3,316±129	-	68.6±9.85	-

Note: SE = Standard error Source: Survey, 2011

In addition, green manure adopters have 15.59% higher TE as compared to the control group, and there is complementary role of green manure with other practice in TE. These figures clearly show the positive role of green manure in enhancing rice yield as well TE of farmers in using other agricultural inputs. Previously, researchers have also found positive roles of green manure on rice yield, and the reasons behind it might be due to improved soil quality as a result of increased organic matter, microbial diversity and aeration (Dahal et al., 1993; Devkota et al., 2006; Pandey, Sah & Becker, 2008). Farmers grow different green manure crops in their land in the spring season (April to June) after harvesting of wheat and before transplanting main season rice (July to October), and incorporate their green biomass into soil during final land preparation for rice.

Out of the various socio-economic variables tested for green manure adoption only irrigation shows significant impact on it. It means households having access to irrigation facility (canal irrigation from river/stream) are more likely to grow green manure crops. This shows that irrigation is one of the constraints for the adoption of green manure crops. Though 55% of the households have irrigation facility and farmers in the group discussion argued that the water level is the irrigation canal reduces by 50% to 75% in the spring season. As a result, many farmers have to wait rainfall for sowing green manure crop, and sometimes they fail to sow the seed of these crops. In contrast to ZT, majority of the farmers (90%) are aware of the role of green manure in the improvement of soil quality. Though there is no significant influence of chemical fertilizer on green manure adoption; however, its negative coefficient indicates that higher chemical fertilizer adopting households are less likely to adopt green manure crop. Green manure adopters invest 16% less amount money for chemical fertilizer than non-adopters.

As in ZT and green manure, improved practice adopters received higher yield and TE as compared to the control group (Table 6.4). This might be due to higher organic matter content in the improved practice adopted fields. The adoption of improved practice is influenced by irrigation, training, fertilizer cost and variety diversification. It means households having irrigation facility, taken agricultural training, and those with higher risk aversion characteristics are more likely to adopt improved practice. But those using higher amount of chemical fertilizer are significantly less likely to adopt improved practice. This also justifies the farmers' behavior in adopting improved practice considering economic perspective though the practice also contributes in saving water (e.g. SRI), reducing pollution and enhancing soil quality.

6.4 Conclusion

This chapter analyzed the influence of households' socio-economic variables on the adoption of ZT, green manure and improved practice in rice using MVP model. Though SCPs provide economic, social and environmental benefits, we analyzed the influence of these variables on the adoption of SCPs focusing on economic consideration. There is positive linkage of SCPs with crop yield and TE which justifies the use of economic consideration in analyzing the adoption of SCPs. The result of MVP model indicates that influence of socio-economic variables varies across SCPs. Households with less family labor, higher operational land, and higher risk aversion characteristics are more likely to adopt ZT. Similarly, those having irrigation facility are more likely to adopt green manure crop. Irrigation facility, training and risk aversion characteristics have significant positive influence on the adoption of improve practice whereas chemical fertilizer has negative impact on it.

Chapter 7. Marketing of rice seed in the study area

7.1 Introduction

It is clear from the previous chapters that in community-based seed production households' grow rice seed but they sell seed in the market through their organizations (CBSPOs). The idea behind rice seed marketing by seed producing households through their organizations is that organizations could minimize the marketing cost due to their potential to increase the economy of scale as compared to an individual household. Also, organizations can hold higher bargaining power in the market chain. The marketing process involves market research, seed collection from household, process, storage and distribution of seed. It means to be successful in marketing seed producing households need to sell maximum proportion of their produced rice to their organization. Similarly, CBSPOs need to cover their full/partial costs involved in marketing. This chapter focuses in these two issues.

7.2 Seed production and sale

The study shows that farmers carry out rice seed production activity in majority of their total operational land (79%). All the sampling households are involved in rice seed production but only 65% of them sell seed in the market. There is quite variation in the proportion of seed sold by households in the market across the districts. Households from Chitwan sell majority of their produce (90%) whereas the proportion of rice seed sold by farmers in Siraha (50%) and Kailali (55%) is less. Here, seed price means the price of rice seed CBSPOs fix for their members at the time of rice harvest (November-December). The rice seed price at this stage is determined by CBSPOs based on the seed colour (brightness), disease and pest infestation, availability of inert materials, and rice grain price. Normally, seed rice gets NRs 2 to NRs 3 higher price

than grain rice. As shown in the Table, farmers of Chitwan get higher price than those from Sirha and Kailali.

Table 7.1 Rice seed production and sale across the districts

Variables	Chitwan	Siraha	Kailali	Overall	p- value
Operational land (ha)	0.91±0.71†	0.90±0.75	1.03±0.7	0.95±0.72	0.54
Production (kg)	3,987±3,200 (100)	2,798±2,405 (100)	3,937±2,579 (100)	3,574±2,789 (100)	0.000
Yield (kg ha^{-1})	4,450±942	3,084±531	3,981±891	3,838±975	0.026
Sold in the market (kg)	2,773±2,402 (90)	1,378±1,214 (50)	1,608±1,441 (55)	2,087±2,328 (65)	0.018
Selling price (Rs kg^{-1})	21±1.26	15±0.96	16.9±2.21	18.02±2.01	0.000
Revenue from seed (Rs)	59,446±62982	21,290±25,602	28,536±28,100	40,953±42,975	0.006

† Standard deviation, figure in the parentheses indicate % of farmers, Source: Survey, 2011

7.3 Household behaviour in selling seed in the market

7.3.1 Conceptual framework

From theoretical perspective it could be argued that households sell most of their produce in the market for economic reasons (to maximize profit) but it might not happen in CBSPOs operated by small farmers, especially in countries where seed industry is in early phase of development (Morris, Smale & Rusike, 1998). For example, in a normal situation, when price of seed increases farmers increase its supply. But this case might not be applicable in subsistence farming. This is because, farmers could sell smaller portion of the total seed produced to meet their households' cash requirement, and the remaining portion could be used to meet their other needs of livelihoods. It means due to economic, infrastructural and institutional constraints (Lanteri & Quagliotti 1997; Omit et al. 2009; Azam, Ima & Gaihaa, 2012) farmers could not sell sufficient seed in the market. Rather, the produced seed might be consumed at home as food or bartered with neighbours for grain or saved for at household for next cropping season. It is assumed that households sell rice seed in the market when they perceive

economic benefit from it. The perception is influenced by demographic, economic and institutional resources.

7.3.2 Empirical method

Heckman selection model (Heckman, 1979) was used for data analysis and this model is considered preferable to OLS if all the households do not participate in the market as it captures the selection bias. Azam, Ima and Gaiha (2012) also applied this model to analyze farmers' market participation in Cambodia. This model consists of two equations. The first equation is called the selection equation that gives the impacts of socio-economic variables on probability of CBSPs' selling seed in the market. The second equation, also called outcome equation, indicates the impact of these variables on volume of seed sold in the market. These two equations were simultaneously modeled using maximum likelihood method as it is more efficient than the two-step procedure. To separate these two equations, the price of seed was used as an identifier in the selection equation. The outcome and selection equations are presented in equation 7.1 and 7.2, respectively.

$$y_i = x_i\beta + \mu_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7.1)$$

$$Z_i^* = w_i\alpha + \epsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7.2)$$

Where, y_i is volume of seed sold in the market, Z_i^* is a latent variable, x_i and w_i are the vectors of explanatory variables, β is the vectors of coefficient, and μ_i and ϵ_i are the error terms. The operational models of the outcome and selection equations are given in equation 7.3 and 7.4, respectively.

Ln seed sold $= \beta_0 + \beta_1$age of HHH $+ \beta_2$education of HHH $+ \beta_3$family labor $+ \beta_4$operational land $+ \beta_5$ln off-farm income $+ \beta_6$irrigation $+ \beta_7$livestock $+ \beta_8$training $+ \beta_9$share $+ \beta_{10}$roof type $+\mu_i$ ……..(7.3)

Market participation = α_0 + $\alpha_1$age of HHH + $\alpha_2$education of HHH + $\alpha_3$family labor + $\alpha_4$operational land + $\alpha_5$ln off-farm income + $\alpha_6$irrigation + $\alpha_7$livestock + $\alpha_8$training + $\alpha_9$share + α_{10}roof type + α_{11}seed price + ϵ_i…….(7.4)

Where, ln is log. Seed sold is the dependent variable used in the outcome equation which indicates the quantity of rice seed sold by farmers in the market. It is possible that farmers' sell seed not only to CBSPOs but also to other actors such as local farmers, agrovet, development projects and so on. But CBSPOs and DADOs in group discussions argued that farmers in the study area rarely sell seed directly to other actors. Rather they sell seed to CBSPOs where they have taken membership, and the CBSPOs after processing (packaging, quality checking and leveling) sell seeds to the aforementioned actors. So, CBSPOs are the first hand buyers of rice seed produced by households. Similarly, market participation is the dependent variable in the selection equation which shows whether farmers sell seed to CBSPOs or not (i.e. dummy variable which takes the value 0 or 1).

A total of 11 socio-economic variables were chosen as explanatory variables considering economic theory, findings from previous literature and experience of farmers as the combination of these strategies would help to draw the relevant variables for the study (Table 7.2). These variables include demographic (age and education of household head – HHH, and family labor), economic (operational land, irrigation facility, off-farm income, livestock and roof type), and institutional (training, collection of share in the organization). The justification for the selection of these variables is given below.

The impact of age and education of HHH was hypothesized positive because age represents experience and education indicates the analytical capability, both of which might have positive impact on households' market participation and volume of seed sold. Similarly, rice seed production is carried out in rural areas where majority of the work is done by their family members. Also, rice farming is seasonal in nature when most of laborers are busy in their own households' activities. Even those wanting to hire laborers might not get them on time and could not operate field activities properly, which might influence the quantity and quality of seed. So, it was hypothesized that family labor (LFU) would have positive impact on both market participation and seed sale volume.

Operational land, irrigation facility (proportion of the total operational land with irrigation facility) and organic manure might have positive linkage on crop yield (Azam, Ima & Gaiha, 2012). So, these variables were assumed to have positive impact on the seed sale. Livestock (LSU) was used as a proxy variable to represent the amount of animal manure applied in the field. Similarly, those having higher off-farm income might be less affected by cash/food shortage, especially from crop harvest until seed sale, would be more motivated towards seed selling. Moreover, the CBSPOs are poor in physical structure (e.g. storage house, grading machine), so they have to store seed at their personal houses for few months after rice harvest until CBSPOs make arrangement to store it in the common place/store. Those having concrete-roofed houses would be more likely to be motivated towards seed selling as they could store the seed maintaining its quality for longer time period than their counterparts. It means in thatched roofed households there might be higher possibility of seed quality deterioration due to leakage of moisture from outside. Lower quality seed might be

rejected in the market and even if accepted households could get less seed price.

Training and household's share (cash deposited at CBSPOs by farmers) are the two institutional variables considered in the study. It was assumed that those receiving training in any aspect of seed management (production, quality control and marketing) might be better off both in the market participation and seed selling volume as it tends to enhance households motivation towards seed selling. Similarly, those deposited cash at CBSPOs as share were assumed to have better performance in seed selling. It is because profit generated from marketing of seed could be distributed to farmers based on proportion of the deposited share. The detail of dependent and explanatory variables used in the study is presented in Table 7.2.

Before running the Heckman Selection model, data were validated for multicollinearity and heteroskedasticity. The VIF method was used to detect multicollinearity because this method is preferred over the correlation coefficient method (Pindyck & Rubinfield 1981). We did not find the problem of multicollinearity in the explanatory variables used in the model as the values are less than 10. The test for homogeneity of variance was conducted using Breusch-Pagan/Cook-Weisberg test for heteroskedasticity, and the null hypothesis of constant variances of the residuals was not rejected ($p>0.25$) across the explanatory variables.

7.3.3 Results and discussion

The study shows that 65.8% of farmers sold rice seed in the market on average 1,356.7kg household^{-1} and this volume is 64% of the total rice seed produced by household. The average operational land for rice seed production per household was 0.95ha (Table 7.2). Average age of HHH was 46.83 years but it varies from 17 – 75 years. Average off-farm income of households was NRs 42,998 and this accounts for

31% of the total annual cash income of the household. The average LSU was 3.86, and major animals raised by farmers include cows, buffaloes, goat and poultry. Majority of HHH in the study area received agricultural training (78.3%) from government organizations and NGOs. About one third of the households (33.8%) had concrete roofed houses.

Table 7.2 Description of variables and expected sign

Variables	Definition	Mean ±SD	Expected sign
Seed sold	Amount of rice seed sold by farmers (kg)	1,356.7±144.3	
Seed selling	1= if they sell the seed, 0 for otherwise	65.8±0.47	
Age HHH	Age of HHH in years	46.83±11.43	+
Education HHH	Formal schooling years of HHH	7.96±4.02	+
Family labor	Labor force unit (LFU)[2] at household	3.44±1.44	+
Operational land	Total land for rice seed production (ha)	0.95±0.36	+
Off-farm income	Annual households' cash income from off-farm sources (NRs)	42,998±38,234	+
Irrigation	% operational land area under irrigation facility	54.5±26.8	+
Livestock	Livestock standard unit (LSU)[3]	3.86±5.77	+
Training	1= if household received seed management training, 0= otherwise	0.783±0.413	+
Share	1= If farmers put share in the organization, 0 = otherwise	0.644±0.480	+
Roof type	1 = if households have concrete roof and 0 = otherwise	0.338±0.645	+
Seed price	Price of rice seed (NRs kg^{-1})	18.02±2.81	+

1 US$ = NRs 82.96 Source: Survey, 2011

About two-third of the household (64.4%) have adopted the practice of depositing share in their organizations. Average price of seed was NRs 18.02 kg^{-1} but it varies from NRs 17kg^{-1} to NRs 24 kg^{-1}.

7.3.2.1 Output from Heckman selection model

Table 7.3 presents the result from Heckman selection model and it shows that the variables chosen for the study fit this model well which is shown by significant log likelihood function (p =0.004). In means the coefficients of explanatory variables used in the model are significantly different from zero. Also, the log likelihood ratio test rejected the hypothesis of the absence of correlation between the error terms of outcome and selection equations ($\rho = 0.690$, $p = 0.027$). This justifies for the estimation of these two equations simultaneously using Heckman Selection model instead of OLS which nullifies the censored observations. Since the equations were modeled using maximum likelihood method, the coefficients of explanatory variables do not represent their average impact on dependent variable. So, marginal impact of explanatory variables on dependent variables was estimated, and these impact values are used to discuss the degree of influence of these variables on dependent variable. The study shows that the impact of most of the explanatory variables is in line with their hypothesized direction. However, the impact of some variables is different between the outcome and selection equations.

The age of HHH has significant positive impact on the volume of seed sale in the market. Households with one year older HHH tend to sell 1.9% higher amount of seed than average aged HHH. The impact of this variable on market participation is not significant. There is significant positive impact of operational land on seed sold volume in the market but its effect on market participation is not significant as in the case of the age of HHH. One ha increase in operational land leads to increase the seed sold volume by 6%. Irrigation also showed significant positive impact on seed sold volume which would be increased by 4.2% with increase in the irrigated land by 1%.

Table 7.3 Impact of explanatory variables on outcome and selection equations

Variables	Outcome equation		Selection equation	
	Coefficient	**Marginal impact**	**Coefficient**	**Marginal impact**
Age HHH	0.020 (0.034)**	0.019(0.036)**	-0.002 (0.772)	-0.001 (0.773)
Education HHH	0.027 (0.401)	0.031(0.342)	0.021 (0.496)	0.006 (0.493)
Family labor	0.0213 (0.254)	0.031(0.402)	0.027 (0.498)	0.009(0.503)
Operational land	0.07 (0.008)*	0.06(0.048)**	0.005 (0.220)	0.0017(0.229)
Off-farm income	0.4(0.301)	0.2(0.231)	0.1(0.746)	0.1(0.856)
Irrigation	0.0765(0.072)*	0.042 (0.072)*	0.112 (0.795)	0.036(0.794)
Livestock	0.004 (0.342)	0.002(0.221)	0.09 (0.094)*	0.071(0.048)**
Training	0.074 (0.76)	0.0212(0.78)	0.182 (0.009)***	0.155(0.014)**
Share	0.081 (0.815)	0.114(0.309)	0.220 (0.037)**	0.190 (0.037)**
Roof type	0.271 (0.212)	0.259(0.217)	0.033 (0.896)	0.010(0.13)
Seed price	-	0.11 (0.084)*	0.08(0.062)*	0.071(0.045)**
Constant	6.433 (0.001)***		2.95(0.008)***	
Wald test (χ^2, 10 = 17.66, p 0.004, Log likelihood statistics = 253.335, Likelihood ratio test for ρ = 0 is 0.690, p = 0.027, Σ (Sigma) = 1.098; λ (Lambda) = 0.757; n = 180, censored observations = 63, uncensored observations = 117,				

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

In contrast to the above findings livestock, training and households' share in CBSPOs showed significant positive impact on the households' participation in the market instead of volume of seed sold. As shown in the table 7.3, one unit increase in LSU leads to increase the probability of households selling seed in the market by 7.1%. Similarly, there is significant positive impact of training on market participation. The training attended households' probability to sell seed in the market is 15.5% higher than the non-attendees. The better performance of trained households in market participation might be due to their better skills on seed quality management, and commercial orientation (Witcombe et al., 2010). To understand the role of training on CBSPOs performance marketing efficiency, four CBSPOs from Chitwan district were selected

considering their audit reports for 2010, and estimated their net profit and return to investment (RTI) using the methodology described by Kubei (2007).

Table 7.4 Cost benefit analysis of rice seed marketing across the four CBSPOs

Particular	**CBSPOs**			
Revenue and its sources	**Unnat**	**Pragati**	**Shreeram**	**Bijbridhi**
Quantity of seed sold (Kg)	407,245	56,000	347,000	268,000
Value of seed sold (NRs.)	14853,327	1932,000	11624,500	9380,000
Revenue from byproducts (NRs.)	3,000	96,000	15,000	8,000
Revenue from machine (NRs.)	144,232	0	300,000	75,000
Staff mobilization (NRs.)	62,689	0	37,800	28,600
(a)Total revenue (NRs.)	**15063,249**	**2028,000**	**11977,300**	**9491,600**
Cost items				
Quantity bought (kg)	422,669	64,000	350,000	270,000
Cost of seed (NRs)	9132,036	1376,000	7350,000	5400,000
Salary to staff (NRs)	362,898	0	250,000	286,000
Processing cost (NRs)	538,224	204,800	346,000	385,000
Depreciation (NRs)	160,839	2,250	108,000	102,000
Training (NRs)	500,000	0	50,000	35,000
Other management cost (NRs)	187,400	60,253	25,300	10,000
(b) Total cost (NRs)	**10881,398**	**60,253**	**56,475**	**29,250**
(c) Profit before interest (NRs) = a-b	4181,850	384,697	3848,000	3273,600
(d) Interest (10%) (NRs) = c*0.1	1088,139	164,330	812,930	621,800
(e) Net profit (NRs) = c-d	**3093,711**	**220,366**	**3035,070**	**2651,800**
Return to investment (%) = e/b	**28**	**13**	**37**	**43**
Profit per kg of seed sold (NRs)	**7.59**	**3.93**	**8.74**	**9.89**

Source: Raw data from audit reports of the CBSPOs, 2010

Since CBSPOs were found to sell not only rice seed but also seeds of other crop and fertilizers, management cost for rice was estimated based on the proportion of annual CBSPOs gross revenue shared by rice seed. Here, RTI is the ratio of net profit to the total cost. Moreover, it was found that due to climatic factors, price fluctuation of rice grain in the market, and rice seed introduced from other areas including India, price of rice seed varies in the market. As a result CBSPOs might not sell all of their produce as

seed but the unsold rice seed is sold in the market in the form of grain with lower price. To see the sensitivity of these organizations with respect to change in seed price due to aforementioned external factors, RTI of these organizations was estimated. The result shows that RTI of CBSPOs spending on training is higher than others. As shown in Table 7.4, RTI of Bijbridhi (43%), Shreeram (37%), and Unnat (28%) was higher than that of Pragati (13%). The reasons for higher RTI of those organizations that invested in training might be due to increased members' skills on technical matters of seed production. As a result, the members sold higher proportion of produced seed to CBSPOs, and the organizations could able to increase their economy of scale.

Further analysis on sensitivity of CBSPOs with change in price shows that Pragati is more sensitive than other three organizations, and its RTI would be negative as this organization has to sell 30% of its output as grain in the market instead of seed. Less sensitiveness of CBSPOs those spending on training might be due to better accountability of their members towards the organizations in producing quality seed and selling higher proportion of rice seed produced at their households. Previous studies also recognized the importance of training for success in community-based seed production (Almekinders & Louwaars, 1999; Cromwell &Wiggins, 1993). Households' share in CBSPOs also showed significant positive impact on market participation. There is 19% higher probability of selling seeds of those who deposited share in CBSPOs than their counterparts. Seed price shows significant positive impact on households' decision to participate in the market. One unit increase in seed price (NRs kg^{-1}) increases the probability of households' selling seed in the market by 7.1%. Seed price has also indirect impact on volume of seed sold in the market as shown from its marginal impact on seed sold volume.

Table 7.5 Return to investment of CBSPOs in different scenarios

Scenarios	CBSPOs			
	Unnat	Pragati	Shreeram	Bijbridhi
Current scenario (from Table 7.4)	28%	13%	37%	43%
Scenario-1 (90% output as seed and 10% as grain)	22%	10%	30%	35%
Scenario-2 (80% output as seed and 20% as grain)	14%	2%	23%	27%
Scenario-3 (70% output as seed and 30% as grain)	9%	-0.5%	18%	22%

Figures in the parenthesis indicate the % reduction as compared to usual scenario

One unit increase in seed price leads to increase the seed sold volume by 11%. The other variables such as family labor, education of HHH and roof type did not show significant impact on seed marketing but it does not mean that they do not have any role in households' decision in selling seed in the market and volume of seed sold.

7.4 Relationship between technical efficiency and seed sold by households

This section measures the relationship between households' TE (Chapter 5) and their seed selling behaviour in the market. Seed selling behaviour is the proportion of rice seed sold by households in the market as compared to the total production. As shown in the scatter plot (Figure 7.1) there is positive relationship between TE and seed sold proportion. The coefficient of the simple linear regression (0.142) indic ates that one unit increase in TE leads to increase the seed sold proportion by 0.142 units. This might be due to higher commercial orientation of the higher technically efficient households as compared to their counterparts. Previous study has also found positive linkage between technical efficiency of households in crop production with their degree of commercialization (Piya, Kiminami & Yagi, 2012)

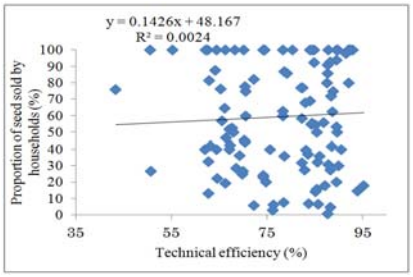

Figure 7.1 Relationship between technical efficiency and seed selling behavior of households

7.5 Conclusion

In this study we analyzed households' behavior in selling seed in the market. The result shows that majority of the households (65.8%) participated in the market and sold 64% of their produce as seed on average. Age of HHH, operational land and irrigation have major impacts on seed sold volume whereas the major impact of livestock, training and share is on CBSPs' participation in the market. Seed price directly impacts on households' market participation, and it has also indirect impact on volume of seed sold in the market. From this study, three variables: training, irrigation and share collection have been found to be important from policy perspective. Also, CBSPOs investing on training for their members showed better performance as compared to the one that has not invested on training with reference to their return to investment and its sensitivity. Similarly, there is positive relationship between technical efficiency and proportion of rice seed sold by households in the market.

Chapter 8. Capacity of seed producer organizations in governance

8.1 Introduction

Governance is defined as the manner in which power is exercised in the management of a country's economic and social resources for development (World Bank, 1991). This term is used in different organizations whether they are informal or formal, and work for profit or non-profit. Most of the CBSPOs of Nepal are in the form of informal groups or cooperatives, and they elect a 7-11 member power exercising body from their members, which is called as 'executive committee'. This committee is headed by a chairperson, and different sub-committees: technical, marketing and finance are formed from executive committee members to facilitate the seed marketing process (Witcombe, Devkota and & Joshi, 2010).

The executive committee members are chosen through democratic principles in one to three years' interval. Since seed marketing is the primary objective of CBSPOs, the governance issue in these organizations is analyzed putting seed marketing in the context. According to McKenzie (2004) organizations are said to capture the essence of good governance if they address the issue of equity, diversity, connectivity, democracy and quality of life. Here, equity indicates how organization addresses the issue of poor members concerns. This chapter measures governance indicators of CBSPOs, analyzes the impact of these governance indicators on economic indicators (i.e. household level technical efficiency score in chapter 5 and proportion of rice seed sold by households to CBSPOs from chapter 7), and discusses the roles of leaders' characteristics in CBSPOs' performance in governance. .

8.2 Conceptual framework

Most of the CBSPOs in the developing countries are the continuation of the traditional farmer groups or cooperatives that were initially promoted by development projects with poverty reduction motive. It means the criteria to participate in such organizations are being residence of a geographical boundary, and involved in agricultural activities. So, participants of these organizations are more likely to have heterogeneity in demographic, economic, and institutional resources. Variation of these resources might lead to inefficiency of CBSPOs in marketing, and sources of the variation might be due to linkage of these resources with variability, frequency and economy of scale of CBSPOs' output (processed seed). For example, poorer members of CBSPOs might supply less proportion of their total produced seed to their CBSPOs as compared to richer members due to food insecurity issue, and so on. Also, being a small organization owned by small farmers, CBSPOs have to address risks from external factors such as government policy, climate, market, and so on.

It is believed that the executive committee could address internal and external factors by developing an appropriate governance system in the organization. For example, incentive system could address the issue of variability, frequency and economy of scale. Similarly, members' participation could also contribute in enhancing organizations' efficiency. For example, households with better informed about their organizations might be more loyal and more accountable towards their organizations' decisions (White, 1984). To address the external factors, CBSPOs could develop mechanical, adaptive, reactive or interactive strategies, and make contingent decisions (Brinkerhoff & Goldsmith, 1990) in line with organizations' efficiency. Governance system contributes in addressing these strategies as it defines a mechanism for

maintaining authority, formality, hierarchy, and information flow. So, CBSPOs capacity means the capacity of executive body in addressing the internal and external factors. Organization's capacity cannot be simply determined by stock of human (organizational structure) and physical resources, but by their proficiency in combining these resources to address the internal and external factors.

One way to look at how much capacity of executive committee members exist is to look at their performance because it is visible and measurable. Moreover, the performance of human factor could be dynamic over time due to its capacity to innovate by integrating lessons or feedbacks from previous events. At this circumstance, the capacity of executive body could be their performance in designing strategies that address the aforementioned internal and external factors. These strategies are participation, incentive system, business plan and linkage. These strategies could contribute in enhancing institutional innovations for organizations' efficiency in different risk scenarios (Cromwell & Wiggins 1993; Mywish, Julie & Ducan, 1999; David, 2004; Bishaw & van Gastel, 2008).

8.3 Selection and measurement of indicators

As discussed in the conceptual framework, participation, incentive system, business plan and linkage are the performance indicators used to assess the organizational governance. However, five sub-indicators under each of the above indicators were developed and assigned them score in accordance with their level of development. For example, in case of 'participation', sub-indicators were developed considering who are the vulnerable group to participate, and in what activities members need to be participated. The study considers women's participation, strategies to address poorer members' concerns in the organizations, members' participation in annual meeting, and

activeness of sub-committee members (technical, financial and marketing sub-committee). Moreover, CBSPOs of Nepal have followed the traditional cooperative structures and membership in these organizations is low. It was hypothesized that addition of new members in addition to those of founder members could enhance CBSPOs social capital and their economy of scale in seed marketing. Similarly, business plan is the key operational document which shows how organizations implement their policies to achieve intended outputs, and to minimize risks from internal and external factors. CBSPOs' business plans were analyzed considering the clarity of sub-committee members' roles to implement annual activities, methods adopted by CBSPOs in market research, product diversification, quality control mechanism and publicity of seed in the market.

CBSPOs argued that members could realize mainly two types of incentives from these organizations such as economic benefit, and transparency of information (social benefit). The sub-indicators reflecting the economic benefits include system of collecting share in the organization as it could enhance members' motivation to sell seed in the market through their CBSPOs, payment system for executive members based on their work load, and incentive system to seed growers so that they could sell majority of seed produced at households to their organizations. Similarly, indicators reflecting transparency in the organization include system of sharing executive committee's decisions to general members, and system for common property management. The common property in this case stands for materials (e.g. sprayers to manage diseases and pests) CBSPOs get from development projects. These materials may be utilized for household's benefit in addition to their common benefit while using at organizational

level. It would be more likely that executive members misuse their power in using these materials in their personal activities if proper system is not established.

Similarly, CBSPOs need to maintain good linkage with agriculture research stations to enhance access to source seed, laboratory facilities for testing seed quality, and to access credit as well as trainings from extension agencies (David, 2004). The detail of sub-indicators associated with the above-mentioned indicators is summarized in appendix 7. Each sub-indicator receives score ranging from 1 to 4, where 4 represent the best performance. After assigning score for each sub-indicator, average score of the major indicators were calculated. Then, using the average score, major indicators are categorized as low, average, good and very good. The relationship of these categories and score is as follows.

If score = <2.5 = low,

If score (mean+0.5 SD) = 2.5-3.1 = average,

If score (mean + SD) = 3.2-3.7 = Good

If score > 3.7 = Very good. Here SD indicates standard deviation

8.4 Results and discussion

8.4.1 Overall performance

In general, CBSPOs have better performance in participation and linkage as compared to business plan and incentive system (Figure 8.1). However, there is quite variation among these organizations with reference to the above mentioned indicators. CBSPOs from Chitwan district (Bijbridhi, Pragati, Shreeram and Unnat) are better in these

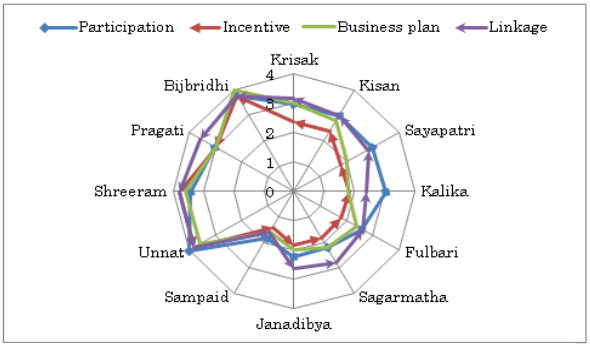

Figure 8.1 Comparison of organizations' performance

indicators than those of Siraha and Kailali (Table 8.5). Among all, Sampaid (CBSPO from Siraha district) showed the least performance with reference to the overall indicators whereas Bijbridhi showed the highest performance.

8.4.2 Indicator wise performance

8.4.2.1 Participation

The study shows that except three CBSPOs of Siraha, women are in the executive committee across CBSPOs (Table 8.1). Presence of women in executive committee means that women could raise their voice in the organizations. But in none of the cases women were in the most influential position i.e. chairperson.

Table 8.1 Performance of CBSPOs with respect to participation

Districts	CBSPOs	Sub indicators						Remarks
		Women	Poor	General assembly	Sub-committee	Entry of new member	Mean	
Kailali	Krisak	4	3	3	3	2	3	Average
	Kisan	4	3	3	3	2	3	Average
	Sayapatri	4	3	3	3	2	3	Average
	Kalika	4	3	3	3	2	3	Average
Siraha	Fulbari	4	2	3	2	2	2.6	Average
	Sagarmatha	2	2	3	2	2	2.2	Low
	Janadibya	2	2	3	2	2	2.2	Low
	Sampaid	2	2	2	1	2	1.8	Low
Chitwan	Unnat	4	4	4	4	4	4	V. good
	Shreeram	4	3	4	3	3	3.4	Good
	Pragati	3	3	3	3	3	3.0	Average
	Bijbridhi	4	4	3	4	4	3.8	V. good

Source: Survey, 2011

As mentioned previously, CBSPOs have heterogeneous members with reference to resources (e.g. land). This means it might be difficult for poorer households to

participate in seed marketing if their organizations do not provide them credit facility and/or early payment for seed that households supply to CBSPOs. It was found that all CBSPOs have policy of prioritizing poor people in credit or timely payment of seed they sell to their organizations. But CBSPOs of Chitwan and Kailali have adopted the practice of early payment for seed. However, two CBSPOs i.e. Unnat and Bijbridhi have adopted the practice of providing both services (credit facility for implementing seed production activities, and early payment of seed for their poorer members). There is no clear cut written mechanism at CBSPOs for selecting poorer members; however, executive committee members argued that they decide their poorer members based on land size and annual households' cash income.

All the organizations have the system of holding general assembly in a yearly basis, and this event is supposed to choose new leadership from members. However, majority of CBSPOs except Shreeram and Unnat the same people are in the executive committee from the beginning of their organizational establishment. It was found that in most of the cases, sub-committees have been formed but they are functioning only in two CBSPOs (Unnat and Bijbridhi). In most of the cases there was no entry of new members since the establishment of the organization, and those who have been added as members after the establishment of CBSPOs, have not got equal number of share to those of founder members. For example, in Shreeram founder members have got six shares with one share equivalent to NRs 5,000 but new comers have received shares @ three shares per member. However, the newly entered members have not been discriminated in Unnat and Bijbridhi.

8.4.2.2 Business plan and its implementation

All CBSPOs have drafted their annual business plan but except in Bijbridhi there was no detail information who should lead on what activity (Table 8.2). Generally sub-committee members are responsible to accomplish the activities of their concerning area but in the absence of clear cut roles and responsibility in their plan it would be less likely to implement activities on time. The second issue in business plan is how CBSPOs do market research. It was found that Unnat and Bijbridhi make consultation with farmers, agrovet and NGOs before preparing their annual business plans.

Table 8.2 Performance of CBSPOs with respect to business plan

Districts	CBSPOs	Sub-indicators						Remarks
		Role clarity	Market research	Product diversification	Quality assurance	Publicity	Mean	
Kailali	Krisak	2	3	4	3	2	2.8	Average
	Kisan	2	3	4	3	2	2.8	Average
	Sayapatri	2	1	3	2	2	2.0	Low
	Kalika	2	1	2	2	2	1.8	Low
Siraha	Fulbari	2	2	3	3	2	2.4	Low
	Sagarmatha	2	1	3	3	2	2.2	Low
	Janadibya	2	1	3	2	2	2.0	Low
	Sampaid	1	2	2	2	1	1.6	Low
Chitwan	Unnat	3	4	4	4	3	3.6	Good
	Shreeram	3	4	4	4	3	3.6	Good
	Pragati	2	3	3	4	3	3.0	Average
	Bijbridhi	4	4	4	4	4	4.0	V. good

But in case of Kalika, Sayapatri, Janadibya and Sagarmatha, there was no system of doing any market research but they produce rice seed based on the accessibility of rice source seed from development projects regardless of the types of rice varieties they receive. In case of Fulbari and Sampaid, they organize meeting with local community before preparing the business plan. The organizations from Kailali and Pragati consult

with local agrovet and local community in this process. The study shows that all the CBSPOs grow both modern and farmers' varieties of rice but only Krisak, Kisan, Unnat and Bijbridhi sell fertilizer to their members in addition to seed.

Similarly, all the CBSPOs sell seeds of other crop varieties; however, maize and kidney bean were found only in Chitwan but wheat is common across the districts. CBSPOs argued that diversifying products help CBSPOs minimize the management costs as well as reduces the necessity of taking loan at organizations. Only CBSPOs of Chitwan sell their seed in the truthfully labeled bags (including the name of crop and variety, germination %, weight, seed treated with pesticides or not and name of the producers' organization). However, Janadibya, Sampaid and Sayapatri CBSPOs sell rice seed without tagging. Among CBSPOs of Chitwan, Bijbridhi sells >70% of the total rice seed production using proper labeling and bagging.

8.4.2.3 Incentive system

All CBSPOs have adopted the practice of collecting cash amounts in their organizations. They call it 'share', and there is a system that profit made by organizations from seed marketing activities would be distributed to the members/shareholders based on the proportion of share amount they deposited in the organization. Less than half of the members have collected share in CBSPOs of Siraha and in two CBSPOs of Kailali. However, majority of the members (>75%) deposit share in CBSPOs at Chitwan. Only two CBSPOs (Unnat and Bijbridhi) distributed the profit generated from seed marketing to their members based on the proportion of their share ownership (Table 8.3). But in other cases the share amount has contributed to increase their organizations' cash reserve (Appendix 8).

Second issue in the incentive system is the provision of incentive to the executives who involve in organizations' management tasks. In case of six CBSPOs (four from Siraha and two from Kailali), there was no system of providing incentive to the executives though they involve in various stages of seed marketing. Similarly, executive members take some resources from the respective CBSPOs on consensus basis especially at the time of major festivals such as Dashain. It means there is no written rule how much resource is distributed to the executive members, and when they are involved in the organizations' tasks. However, in case of three CBSPOs of Chitwan (Unnat, Bijbridhi and Shreeram) executive members are paid based on their involvement, especially in roughing (i.e. removal of diseased or unwanted plants/weeds from seed production plots).

Table 8.3 Performance of CBSPOs with respect to incentive

Districts	CBSPOs	Sub-indicators					Mean	Remarks
		Share collection	Incentive to executives	Incentive to growers	Information management	Common property		
Kailali	Krisak	3	2	2	2	3	2.4	Low
	Kisan	3	2	2	2	3	2.4	Low
	Sayapatri	2	1	2	2	2	1.8	Low
	Kalika	2	1	2	2	2	1.8	Low
Siraha	Fulbari	2	1	2	2	2	1.8	Low
	Sagarmatha	2	1	2	2	2	1.8	Low
	Janadibya	2	1	2	2	2	1.8	Low
	Sampaid	2	1	2	1	1	1.4	Low
Chitwan	Unnat	4	4	4	4	3	3.8	V. good
	Shreeram	4	4	4	4	3	3.8	V. good
	Pragati	4	3	2	3	3	3.0	Average
	Bijbridhi	4	4	3	4	4	3.8	Very good

It was found that Unnat, Bijbridhi and Shreeram provide seed and fertilizer in subsidy to their seed growers, but other organizations have not developed such practice. Transparency of organizations' decision to their members is considered to play vital role in improving cohesion among the members in any organizations. Members who are more informed about their organizations' decision are more likely to be accountable towards their organizations (White, 1984). It was found that CBSPOs of Chitwan have better performance in record keeping as compared to CBSPOs from other two districts. Moreover, CBSPOs get different materials (such as sprayers, grading machine and so on) from development projects. However, only Bijbridhi has adopted the practice of providing these materials to their members for their household activities on payment basis (for example, members have to pay NRs. 20 while using organization's one sprayer for one day).

4.4.2.4 Linkage

Nepal Agricultural Research Council (NARC) provides source seed to seed producers no matters seed production is carried out individually or by group, but priority is given for farmers engaged in CBSPOs. It means it is easier for farmers to access source seed if they approach to NARC through their organizations. It was found that except CBSPOs of Siraha all other organizations were found to have bought rice source seed visiting NARC stations. However, the two-way communication has been established only in Chitwan. It means in Chitwan not only CBSPOs visit NARC stations to access source seed but NARC's professionals also make visit to CBSPOs in the process of monitoring their rice crop at field. CBSPOs argued that NARC professionals' visit has been useful to enhance seed quality as farmers get technical advice from these professionals in pests and disease management as well as roughing. CBSPOs were also

found to have consulted with seed lab for testing seed quality, and DADOs to access agricultural training. The relationship of CBSPOs with seed lab and DADOs is also similar in these districts as it is with NARC stations.

One of the reasons behind the better linkage of government professionals with CBSPOs might be due to the provision of incentive system developed by CBSPOs to the government officials during their visits. Some CBSPOs members argued that they pay travel costs of government professionals and provide them additional money as pocket allowance. All CBSPOs of Chitwan, and Krisak CBSPO of Kailali were able to access cash grant (NRs 60,000) as business start-up fund from the DADOs. Using this fund together with share money collected from their members (in Chitwan district) CBSPOs have developed their physical structures such as seed grading machine, threshing floor, etc (Appendix 8).

Table 8.4 Performance of CBSPOs with respect to linkage with service providers

Districts	CBSPOs	Sub-indicators						Remarks
		Agri. Research	Laboratory	Agri. Extension	Village Development Committee	Government bank	Mean	
Kailali	Krisak	3	3	4	3	3	3.2	Good
	Kisan	3	3	4	3	2	3.0	Average
	Sayapatri	3	2	3	4	2	2.8	Average
	Kalika	3	2	3	2	2	2.4	Low
Siraha	Fulbari	3	3	3	2	2	2.6	Average
	Sagarmatha	3	3	4	2	2	2.8	Average
	Janadibya	3	3	3	2	2	2.6	Average
	Sampaid	2	2	2	1	1	1.6	Low
Chitwan	Unnat	4	4	4	3	4	3.8	Very good
	Shreeram	4	4	4	3	4	3.8	Very good
	Pragati	4	4	4	2	4	3.6	Good
	Bijbridhi	4	4	4	3	4	3.8	Very good

Moreover, even if the National Seed Policy 2000 envisioned VDC as an important local resource center to support CBSPOs from government side, there is poor coordination of CBSPOs with VDC. Except in CBSPOs of Sayapatri which built a seed storage house with partial support from VDC, there is poor communication between VDCs and CBSPOs. As in the above cases, CBSPOs of Chitwan have taken loan from Nepalese government bank named as 'Krisibikash Bank' which has a mandate to provide loan to the farmers. In other districts CBSPOs have not taken loan from the same bank though it has branches in other districts as well. Executive members from these organizations argued that they could not access loan from the bank not being able to put collateral. In spite of the requirement for putting collateral in Chitwan, executive members were found to put their households' properties, especially land, to get credit for their organizations.

8.4.4 Relation of governance indicators with economic indicators

There is positive impact of governance indicators on household level TE and proportion of seed sold by households in the market. However, the degree of impact of the governance indicators on marketing is higher than they have on TE. The coefficient for the impact of participation on technical efficiency is 7.68, which means that one unit increase in participation tends to increase the TE of household by 7.68 units. It is also clear from this analysis that participation has the highest impact on TE as compared to the other governance indicators. Similarly, linkage has the highest impact on marketing and its coefficient is 28.88 (Figure 8.2). It means one unit increase in linkage leads to increase the households' seed sold proportion by 28.88 units.

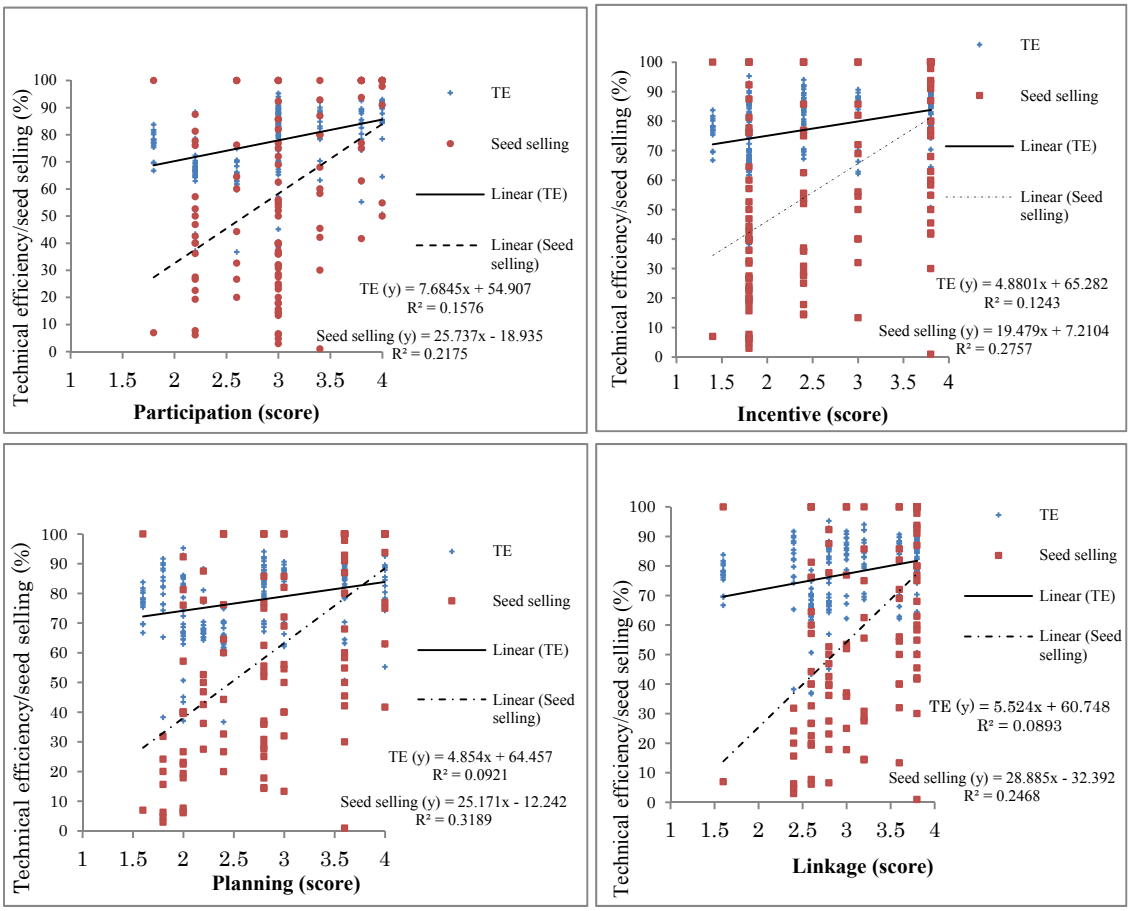

Figure 8.2 Impact of governance indicators on technical efficiency (TE) and seed selling (n = 180)

To complement the above analysis, the governance indicators and economic indicators were summarized at CBSPOs level (Table 8.5). It is clear from the table that CBSPOs of Chitwan have better economic and governance indicators as compared to those from other two districts. Moreover, the governance indicators were also compared with characteristics of the CBSPOs' leaders (Table 8.6) considering that their leaders characteristics could be related to organizations' performance in governance. Though there are 7-11 members in the executive committee of the selected CBSPOs, chairperson and secretary were chosen in the analysis as CBSPOs argued that these positions are most influential in organizations' decision making process. So, characteristics (age, years of formal education and training) of these two positions were

compared with CBSPOs' governance indicators. Here, age represents experience whereas education and training represent the intellectual ability of the leaders. It means CBSPOs with higher intellectual leaders can have better performance in governance. The result shows that there is similarity in age of the leaders across CBSPOs. However, variation exists in education level and leaders 'attendance in business plan training. As shown in Table 8.6, leaders' education is higher in Chitwan as compared to Siraha and Kailali. There is also similar trend in average education level of CBSPOs members across the districts (Chitwan: 10.4 years, Kailali: 6.0 years and Siraha: 6.5 years) (Appendix 7). It means average education level of general members reflect the leaders' education in this study. Similarly, CBSPOs' leaders from Chitwan district have got business plan training from development agency whereas it was not taken by these leaders in other districts. The attendance of business plan training by CBSPOs' of Chitwan might be due to their higher education level as higher educated leaders might have better linkage with development projects.

Previous studies have also recognized the importance of education for the better performance of agricultural cooperatives (Witcombet, Devkota & Joshi, 2010; Acharya, 2009) as the leaders having these skills could show better performance in the organizational governance. Nkhoma (2011) argued that illiterate leaders are more likely to be corrupt and opportunistic, which turned the organizations towards financial mismanagement and nepotism. These types of leaders might not want to develop system for proper allocation of incentives in a transparent way.

Similarly, accountability is another aspect affected by low education level. Generally, less educated leaders are less accountable towards what they are supposed to do. These leaders get better opportunity to misuse power such as diverting activities in accordance

to their own priorities without doing proper consultation with other members or designing activities in the interest of political parties (Chriwa et al. 2005). It is clear from the study that especially three CBSPOs: Bijbridhi, Unnat and Shreeram are better in both economic and governance indicators. These three organizations were also promoted by development projects but leaders of these organizations were school teachers (higher educated). Being local teachers, they had capacity to motivate farmers to organize in group/cooperatives, developed planning and incentive system, and could make linkage with development projects to access resources. They argued that system of collecting share in the organization is vital in the success of CBSPOs because this system makes the member accountable towards their organizations.

Table 8.5 Household level governance and economic indicators across CBSPOs

District	CBSPOs	Participation	Planning	Incentive	Linkage	Technical efficiency (%)	Seed sold (%)
Kailali	Krisak	3	2.8	2.4	3.2	85.6	63.4
	Kisan	3	2.8	2.4	3.0	85.3	49.4
	Sayapati	3	2	1.8	2.8	82.8	53.2
	Kalika	3	1.8	1.8	2.4	82.4	15.0
Siraha	Fulbari	2.6	2.4	1.8	2.6	67.5	62.4
	Sagarmatha	2.2	2.2	1.8	2.8	73.1	90.1
	Janadibya	2.2	2	1.8	2.6	66.0	37.6
	Sampid	1.8	1.6	1.4	1.6	73.6	53.4
Chitwan	Unnat	4	3.6	3.8	3.8	87.6	92.4
	Shreeram	3.4	3.6	3.8	3.8	87.0	67.9
	Pragati	3	3	3.0	3.6	83.5	61.0
	Bijbridhi	3.8	4	3.8	3.8	85.0	89.0

When these organizations implemented share collection policy, some members dropped the organizations because they were not confident about safety of their investment. But after few years (especially in Unnat), some of dropped out farmers

rejoined the same organizations looking at CBSPOs' progress. It means better performed CBSPOs have experienced co-evolutionary pathway which is driven by efficiency gain, and this phenomena is similar to what Morris & Smale (1998) used to discuss the evolution of maize seed industry.

Table 8.6 Comparison of CBSPOs' governance indicators with their leaders' characteristics

Districts	CBSPOs	Participa.	Planning	Incentive	Linkage	Chairperson			Secretary		
						Age	Edu.	Train.	Age	Edu.	Train.
Kailali	Krisak	3.0	3.0	2.4	3.2	43	7	1, 2, 5	42	10	1, 2, 5
	Kisan	2.8	2.8	2.4	3.0	58	4	1, 2	45	7	1
	Sayapati	2.0	2.0	1.8	2.8	45	10	1	42	10	1, 2
	Kalika	1.8	1.8	1.8	2.4	48	8	1, 2,	49	10	1
Siraha	Fulbari	2.4	2.4	1.8	2.6	66	8	1, 2	35	14	1, 5
	Sagarmatha	2.2	2.2	1.8	2.8	39	14	1,2,3,5	45	10	1
	Janadibya	2.0	2.0	1.8	2.6	35	12	1,2,3,5	29	10	1
	Sampid	1.6	1.6	1.4	1.6	38	12	1,2,3	45	10	1
Chitwan	Unnat	3.6	3.6	3.8	3.8	45	14	1, 2, 3, 4	50	12	1,2,3,4
	Shreeram	3.6	3.6	3.8	3.8	60	12	1, 2, 3, 4	60	12	1
	Pragati	3.0	3.0	3.0	3.6	67	12	1,3,5	32	12	1, 5,4
	Pithuwa	4.0	4.0	3.8	3.8	70	11	1,2,3,4,5	47	14	1,2,3,4,5

Note: Participa. = Participation, Edu. = Education i.e. formal schooling years, Train. = Training (1= Seed production, 2= Marketing, 3= Leadership, 4= Business plan, 5= Account)

8.5 A Case of Institutional innovation in Bijbridhi CBSPO

8.5.1 Motivation for seed production

Bijbridhi CBSPO was evolved from a group named as 'Pithuwa Biu Utpadak Krisak Samuha' (PBUKS), which was formed in August 1994 by nine farmers. These farmers were involved as contract seed producers for Agricultural Input Corporations (AIC) before that time for three years. Being contract seed growers they realized that seed production would be profitable than grain production in cereals. Farmers also

thought that AIC was paying them low rate for their seed justifying that seed produced by these farmers was of poor quality (low physical and genetic purity), and farmers were producing seed in small quantity. Even if they had a contract with AIC there was no certainty that AIC would buy seed from them every year as per the contract agreement. Due to these problems, farmers decided to form their own organization to produce and sell seed in market. These farmers also got motivation from NGOs and DADOs to take part in seed production through an organized way.

8.5.2 Functioning of group

The group set up the objective of improving the socio-economic condition of their members by involving in seed production and marketing. This objective was not set by farmers themselves but by development projects which were implemented in the area with the poverty reduction motive. After setting up the objective, the group was legally registered in DADO of Chitwan in August 1996. Then, all the group members started producing improved seeds of rice, wheat, maize, lentil and kidney bean, collecting source seed from NARC stations. These stations are National Maize Research Program, for rice, wheat and maize; and National Grain Legume Research Program for lentil and kidney bean. Looking at the benefits taken by these farmers, neighboring farmers, who were growing the aforementioned crops as grain, approached the group for membership. The group decided to increase its members to enhance its economy of scale, and by 2001 the members in the group increased to 61. The newly entered members had to pay membership fee @ NRs 50 per member (later it was increased to NRs. 100). The major attraction of new members to enter into the group was that they would get extension facilities from DADO (technical training, exposure visit), agricultural research stations (source seed, training), seed laboratory (seed testing facility), and NGOs (training,

visits).

The group members formed an executive committee where the members were selected democratically from the general assembly of organized members, and the committee had two years tenure. There were three sub-committees under the executive committee to deal with seed technical and management issues: technical, marketing and finance. The technical sub-committee had to involve in the selection of seed grower farmers, maintenance of isolation distance of seed plots, removal of diseased and off-type plants, seed quality inspection at threshing, and pesticide application. The committee considers seed quality at threshing from the perspective of seeds infected with disease and pest, inert materials, and seed color. Seed growers argued that seed color is the most important seed quality indicator for local farmers as this indicator indicates whether the seed crop properly matures or not. Seed crops planted late or soaked due to heavy rain during harvesting could not produce bright shining color on seed coat.

In addition to collecting fund from group membership, farmers also started collecting monthly saving from their members (initially it was NRs 50 per member, and later increased to NRs 100). Similarly, interest of loan provided to their members, commission from seed sales (members had to pay NRs 2 per kg of seed sold to the group fund, charges imposed on outside groups for visits (initially it was NRs 10, and later increased to NRs 500) and other earnings such as gift/prizes also contributed to the group reserve.

8.5.3 Challenges in the group

In spite of the concerted effort from various organizations for enhancing the group capacity, the group saving could not substantially increased (NRs 15,000 in 2005 as compared to NRs. 12,000 in 2000). The executive members argued that major reason for lower performance of the group was due to the fact that the group became completely dependent on extension agencies in accessing source seed and selling their seed. Extension agencies bought most of the seed CBSPO produced for their project even paying comparatively higher price than it was in the market. As a result, in some years when projects did not buy seed, farmers could not sell seed as per their plan as the price set by the group was quite higher than that of other actors. It was due to the fact that the group set the price with reference to what development projects were paying for their seed in previous years. Also, cases of conflict started increasing among the members due to organizations' inability to develop physical resources for seed processing and marketing as a result of low group saving, and also poorer members of the organizations started raising voice for their benefit from the organization.

8.5.4 Conversion of group to company

In 2005, some member of the group, those involved in technical and marketing sub-committees decided to form a producer seed company. They argued that low group fund was the main reason for them not being able to develop physical structure, and the proposal for setting up the company was discussed in the group. However, only 16 members agreed on the proposal and they formally registered the seed company in 2006 in accordance with the Nepalese Company Act 2004. All the members, deposited share amounting NRs 4,000 to NRs 10,000 and they bought a seed grader machine and build a seed storage house using fund collected from share amounts from members and grants

they received from development agencies such as DADO (NRs 25,000) and District Development Committee (NRs 20,000). Similarly, the responsibility in the executive committee members of the organization was given based on their competency and commitments. For example, the organizational manager was selected from the members with bachelor level education in commerce paying his monthly salary. The manager is also the secretary of the organization, and the executive committee has delicate him full authority to implement activities authorized by the committee. In a meeting, the manager of Bijbridhi argued that he collects information regarding amount of rice seed available with competitors and associated price routinely from the market by telephone calls. He mentioned that collecting these types of information is important to design strategies for addressing uncertainty of seed price.

The company realized that the seed produced only by the existing members would not be sufficient to cover their management cost. So, they contracted with 300 growers (with about 300 ha) residing in six VDCs (Pithuwa, Jutpani, Chainpur, Kathar, Padampur and Shaktikhore), and one municipality (Ratnanagar). They also increased the number of crops and their varieties in seed production and marketing, and their seed sold volume started increasing over the years (Figure 8.3). Majority of seeds of these varieties (>75%) are sold in labeled bags with the brand name *'Kisan Ko Biu'* with different packaging sizes, and the type of packaging materials was also based on

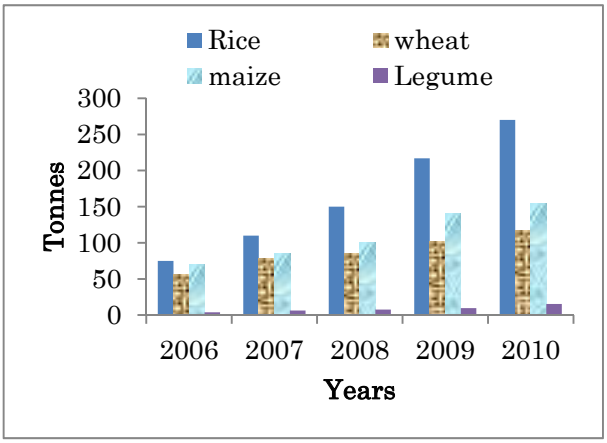

Figure 8.3 Rice seed sold by Bijbridhi over the years

consumers' demand. For example,

Moreover, the company used to sell majority of its seed to NGOs, DADOs, and local farmers. In 2010, the company sold 557.3t of seed where the share of rice seed was 45%. There is increasing trend of rice seed sold by the organization (Figure 3), majority of which was sold to agrovet (>90%), and 40% of their produce is consumed within Chitwan district mainly through agrovet in the surveyed year. The company record shows that its seed has been disseminated to 35 districts of Nepal. The company has developed incentive system to seed producers, executive members, and have good linkage with government agencies and NGOs. They produce both local varieties and improved crop varieties to address the consumers' demand. The members of these groups also participate in various meetings related to agriculture, seed system in the country.

8.5.5 Relation between group and company

The company has been able to maintain good relation with PBUK, 25 members of this group are also the shareholders in the company. The non-shareholders of the company, especially the poorer members of the group, are also benefitted from the company as they could access quality seed from the company and increase their production. Some of group members sell seed to the company. Similarly, the company provides local farmers seed, chemical fertilizer and bio-fertilizers, even in loan if needed. Moreover, the company is also benefitted from the group as it takes loan from PBUK as the members are still continuing monthly saving from the beginning of its organizational establishment. The committee members argued that PBUK provided foundation for the establishment of Bijbridhi. This is because the members those involved in PBUK internalized the benefits from seed production and marketing

activities. As a result they developed confidence in seed management activities and opened a private company using their own investment.

8.5.6 Reasons for success of the group

Among the all CBSPOs surveyed in the study, Bijbridhi CBSPO was found most successful as it has covered the marketing cost (Table 7.4) and provided additional benefits to the members. Also, it has captured the issues of both small and large farmers by including both farmers' variety and modern varieties in seed production plan. Moreover, it has developed strategies to address the risks that create organizational inefficiency in seed marketing by designing governance strategies. There might be various factors for the success of this organization but one clear cut difference between Bijbridhi CBSPO and other poor performing CBSPO (such as Pragati) is education of leadership. The group PBUK was led by high school teacher, some other primary school's teachers and retired staff of agricultural extension agencies were included as members in the group. Due to the educated leaders, the group became able to develop incentive system in the organization, and developed seed processing structures (grading machine, seed storage and threshing floor) through public private partnership approach. Even after changing the organization structure from group to company, the educated and experience people were selected in the executive committee. Similarly, sub-committee members were also chosen based on their skills and commitments. These leaders also were able to make connection with development projects working in the district to access trainings on various dimensions of seed management. It does not mean that leadership is the only factor for the good performance of Bijbridhi CBSPO. Education of seed consumers, accessibility of agricultural inputs such as irrigation facility, source seed and extension facility is better in Chitwan district. All these factors might have

triggered the organization towards better performance.

8.5.7 Challenges for the company

On the question of the sustainability of Bijbridhi, the executive members opined that source seed, irrigation, and uncertainty management are the key challenges. Out of the 10t rice source seed demanded in 2010, they received only 50% of it and in many cases the source seed was poor in terms of germination and genetic purity. The uncertainty is mainly created by changing rainfall trend. This organization could not collect 20t of rice variety (Hardinath 1) due to poor seed quality as a result of heavy rain during rice harvesting.

8.6 Conclusion

This chapter measured the governance of CBSPOs with respect to participation, business plan, incentive system and linkage. The governance indicators provide basis to enhance organizations' efficiency in marketing by addressing the internal and external factors. The result shows that in general CBSPOs have better performance in participation and linkage as compared to incentive system and business plan. There is positive impact of governance indicators on households' economic indicators i.e. technical efficiency and proportion of rice seed sold in the market. This provides the basis that even if extension agencies facilitate CBSPOs for designing their governance indicators benefits will be realized at household level. The better performance of CBSPOs in governance may be due to their higher educated leaders.

Chapter 9. Conclusions and recommendations

This study analyzed the sustainability of community-based rice seed production from system perspective, putting seed producers and seed consumers in the context. Here, sustainability is analyzed from the perspective of 'sustainable development'. This consideration is important in analyzing the sustainability of community-based seed production systems, especially those which are in early phase of development. This study is focused on seed producers, and it attempts to address the question of how seed producers get economic benefit from seed production and how this benefit would continue in the future. Since seed production is primarily an economic activity, social and environmental aspects were analyzed with respect to their linkage with economic issue. Efficiency gained by seed producers in production and marketing stages is the economic indicator, whereas organizational governance and the adoption of soil conservation practices are social and environmental indicators, respectively.

It is clear from the analysis that governance indicators have positive impact on economic indicators (technical efficiency and proportion of seed sold by household). Similarly, soil conservation practices have also positive link with crop yield and technical efficiency. This justifies the rationale for using this approach in the analysis. It also shows the mechanism for strengthening community-based seed production system.

Seed producers in the study area are small farmers and these categories of farmers could not enhance their efficiency in utilizing high input technologies but by proper allocation of their existing resources such as operational land, seed, fertilizer, labor, livestock and chemical fertilizer. Households with irrigation facility and with higher educated household head have significantly higher efficiency level. These two variables have also positive impact on households' participation in the market. Similarly, access

to irrigation has also positive impact in adopting green manure in the field. The green manure harmonizes farmers' objectives to increase the crop yield as well as to improve soil quality. Improved soil quality could also make a basis for continuity of benefits to seed producers from rice seed production. Similarly, education of household head and access to irrigation facility has also positive impact on consumers' behavior in buying rice seed from the market. Moreover, this study also recognized the importance of education for enhancing CBSPOs' performance in governance, which is crucial to enhance efficiency of seed growers by addressing the issue of participation, business plan, incentive system and linkage. It means extension agencies intended to strengthen the sustainability of rice seed production in the study area should focus on education and irrigation issues.

The government agency should prioritize for enhancing formal education in the study area for the long term. However, in the short run, extension agencies could contribute to enhance education level of seed producers on technical and marketing aspects of seed production through vocational trainings or demonstrations. This is because average age of HHH head is over 46.8 years, and the provision formal education for these farmers might not be appropriate. This could also apply for seed consumers because education has also positive impact on consumers' behavior in buying rice seed from the market. It means considering the low education of the consumers, extension agencies could organize field demonstrations plots of improved seed produced by CBSPOs to motivate the seed consumers in buying seed from the market. Also, extension agencies could motivate consumers in buying seed from the market by providing subsidy on seed produced by CBSPOs for the short run. Though Nepal has adopted group approach in the agricultural extension system, about half of

the seed consumers were not found to be engaged in any agricultural groups or cooperatives. It means group formation and strengthening in needy areas, and arrangement for making linkage between CBSPOs and seed consumers' organizations would be another strategy for educating seed consumers about seeds supplied by seed producers.

Since CBSPOs included in the study were not established to develop them into business organizations but to contribute in poverty reduction strategies through self-help approach as per the motivation they got from development projects. It means it's a challenging job for executive committee how to manage the conflict arising from variability of their members' socio-economic characteristics, technology, and external factors. It is clear from the analysis that executive leaders' education level could be one of the factors for better organizations' governance. However, how higher educated, dynamic and talented leaders could be introduced in CBSPOs leadership is the key issue. Since CBSPOs is a democratic organization, it would be the best idea if members would be able to choose higher educated leadership from among the existing members if possible. This is because in most of the cases lower educated members are in executive positions from the beginning of organization establishment even if the higher educated members available in the organizations. One of the reasons might be lack of incentive system (financial gain as well as transparency) that would not motivate educated leaders to take responsibility of these positions. Also, existing leaders, in some cases, are not interested to leave the position as they might be taking personal advantages from these organizations as well as from development projects being in the leadership. At this circumstance, development agencies could facilitate CBSPOs in selecting educated and talented leaders from the existing members, and support them for designing appropriate

organizational governance, especially in business plan and incentive system. If higher educated leaders are not available, CBSPOs could invite educated shareholders in their organization from the local community or extension agencies could arrange higher education for CBSPOs leaders. There is also necessary to incorporate business development / enterprise development concepts trainings/academic curricula of academic (agricultural university) and development agencies. It means integrating these concepts in the course curriculum of extension and education agencies could contribute in making CBSPOs more dynamic. Moreover, if higher educated trained leaders start CBSPOs, they could properly address the social, economical and environmental issues as discussed in this dissertation, and could gain higher efficiency in production and marketing. This does not mean that education is the only important aspect to be considered to enhance the performance of community-based seed production.

Similarly, irrigation issue in the study area could be addressed by increasing investment to build up irrigation canal to access irrigation for existing rivers or from underground source. Extension agencies could support irrigation facility based on comparative advantage of available sources. However, these initiatives might demand huge resources; development of alternative strategies that enhance water use efficiency such as use of drought tolerant crop varieties would be useful. This might be possible through local level participatory research and development activities, utilizing the farmers' local knowledge and resources.

Moreover, it is clear from the adoption study that farmers buy both modern and farmers' varieties but majority of these varieties grown by farmers in these areas have not been released or registered by the government. Marketing of the seeds of these non-registered / non-released varieties is considered illegal according to the revised seed

act 2008. It means if farmers grow these illegal varieties or CBSPOs grow or sell these varieties, government agencies will not provide extension facilities in these varieties. At this circumstance, government agency (National Seed Board) should explore the reasons for poor registration of these varieties and address the issue accordingly.

End Notes

[1]GHI is the measure of food insecurity in the world. It is estimated considering under nourishment, child mortality and child under weight. The value of the index is classified into five categories: <4.9 low, 5-9.9 = moderate, 10-19.9 = serious, 20-29.9 alarming, >30 extremely alarming. Out of 119 countries facing the problem of hunger, 40, 22, 17, 17 and 3 countries fall under low, moderate, serious, alarming and extremely alarming categories, respectively. Burundi has the highest GHI (37.1) (IFPRI, 2012)

[2]LFU is the measurement of labor force, where people from 15-59 years old regardless of their sex were categorized as 1 person = 1LFU, but in case of children (10-14 years old) and elderly people (>59 years old) 1 person = 0.5 LFU

[3]LSU is the aggregates of different types of livestock kept at household in standard unit calculated using the following equivalents; 1 adult buffalo = 1 LSU, I immature buffalo = 0.5 LSU, 1 cow = 0.8 LSU, 1 calf = 0.4 LSU, 1 pig = 0.3 LSU, 1sheep or goat = 0.2 LSU and 1 poultry or pigeon =0.1 LSU (CBS, 2003; Baral, 2005)

[4]Irrigation cost in the study area was calculated by multiplying the time of farmers with respective man day rate in case of households using public irrigation source such as surface water irrigation scheme, and if household used underground water through tube well rental cost of tube well was calculated

[5]Land rent was estimated considering the value of rice farmers would get from share cropping

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Appendices

Appendix 1 Profile of community-based seed producers selected for the study

District	VDC /Municipality	CBSPOs name	Years of establishment	Total Members	Involved in rice seed production	Surveyed households
Kailali	Munuwa†	Kisak[b]	2001	58	28	15 (53.7)
	Tikapur‡	Kisan [a]	1997	26	20	15 (75)
	Masuriya†	Sayapatri [a]	2009	20	15	15(100)
	Chaumala †	Kalika [a]	1999	18	15	15 (100)
Sub-total				120	78	60 (80)
Siraha	Padariya †	Fulbari	2009	20	19	15 (78.9)
	Gadha †	Sagarmatha [a]	2007	25	20	15 (75)
	Gadha†	Janadibya [a]	1998	25	23	15 (65.2)
	Siraha‡	Sampaid [b]	2009	20	15	15 (100)
Sub-total				90	77	60 (77.9)
Chitwan	Patihani†	Unnat [b]	2003	98	64	15 (23.43)
	Parwatipur†	Shreeram [b]	2003	54	45	15 (33.33)
	Saradanagar†	Pragati [b]	2001	74	48	15 (31.25)
	Madhabpur†	Bij Bridhi[c]	1998	48	28	15 (53.57)
Sub-total				270	185	60 (32.43)

† =VDC, ‡ Municipality; [a] = Cooperative, [b] =Group and [c] = Producer company (converted from group in 2006), Figure in the parenthesis indicates the proportions of households representing the total rice seed growers

Detail names of CBSPOs: Krisak = Bij Bridhi Krisak Sahakari Sanstha; Kisan = Krisak Bij Bridhi Krishi Sahakari Sanstha; Sayapatri = Sayapatri Biu Utpadak Krishi Samuha; Kalika = Kalika Biu Utpadak Samuha; Janadibya = Janadibya Krishi Sahakari Sanstha; Fulbari = Salhes Fulbari Biu Utpadak Krisak Samuha; Sagarmatha =Sagarmatha Bahuudeshiya Sahakari Santha; Sampaid = Sampaid Biu Utpadan Samuha; Unnat = Unnat Bij Bridhi Krisak Samuha; Shreeram = Shreeram Bij Bridhi Krisak Samuha; Pragati = Pragati Bijbridhi Krisak Samuha; and Bij Bridhi = Bij Bridhi Company

Appendix 2 Profile of seed consumers selected for study in the area

District	VDCs/Municipality	Total number of households	Households chosen for the study
Chitwan	Jagatpur	30	15 (50)
	Gitanagar	45	15 (33)
	Birendranagar	27	15 (56)
	Mangalpur	29	15 (52)
Siraha	Hakpada	30	15 (50)
	Sisbanai	33	15 (45)
	Mahadevpratoha	19	15 (78.9)
	Betauna	25	15 (60)
Kailali	Gadariya	27	15 (55.5)
	Durgauli	23	15 (65.2)
	Joshipur	28	15 (53.5)
	Udasipur	41	15 (36.5)

Figures in the parenthesis indicates the proportion of the total households

Appendix 3 Socio-economic characteristics of households in the study area

Variables	Chitwan	Siraha	Kailali	Overall
Gender of Household Head (HHH) P-value = 0.13				
Male	54 (90.0)	51 (85)	46 (76.7)	151 (83.8)
Female	6 (10.0)	9 (15)	14 (23.3)	29 (16.2)
Caste/Ethnicity P value = 0.00***				
Brahmin/Chhetri	59 (98.3)	35 (58.3)	20 (33.3)	114 (63.3)
Janajati	1 (1.7)	19 (31.7)	40 (66.7)	60 (33.3)
Dalit	0 (0.0)	6 (10.0)	0.0	6 (3.4)
Major occupation of HHH, p value = 0.06*				
Agriculture	53 (88.3)	52 (86.7)	58 (97.0)	163 (90.5)
Salary job	7 (11.7)	5 (8.3)	2 (3.0)	14 (7.8)
Business	0 (0.0)	3 (5)	0 (0.0)	3 (1.7)
Family size, p value = 0.4				
Small (<5 members)	29 (48.3)	26 (43.3)	22 (36.7)	77 (42.8)
Medium (>5-10 members)	30 (50.0)	29 (48.3)	34 (56.7)	93 (51.7)
Large (>10 members)	1 (1.7)	5 (8.4)	4 (6.6)	10 (5.5)
Average	5.9	6.5	6.8	6.4
Education of household head, p = 0.015**				
Non-formal	0 (0)	12 (20.0)	14 (23.33)	26 (14.5)
Primary level (1-5)	9 (15)	16 (26.67)	13 (21.67)	38 (21.1)
Secondary level (6-10)	26 (43.30)	21 (35.0)	27 (45.0)	74 (41.1)
College education (>11)	25 (41.67)	11 (18.33)	6 (10.0)	42 (23.3)
Average	10.4	6.5	6.0	7.6
Livestock unit p = 0.001***				
Small (<5LSU)	49 (81.7)	60 (100)	55 (91.7)	164 (91.1)
Medium (5-10LSU)	5 (8.3)	0 (0.0)	5 (8.3)	10 (5.5)
Large (>10LSU)	6(10.0)	0 (0.0)	0 (0.0)	6 (3.4)
Average	7.7	1.6	2.2	3.8
Land holding characteristics P= 0.16				
Small (<0.5 ha)	20 (33.3)	9 (15)	14 (23.3)	43 (23.9)
Medium (0.5-2 ha)	36 (60.0)	44 (73.3)	38 (63.3)	118 (65.6)
Large (>2 ha)	4 (6.7)	7 (11.7)	8 (13.4)	19 (10.5)
Average (ha)	0.95	1.39	1.34	1.22

Note: Figures in the parentheses indicate percentage, ***, ** and * indicate significance at 1%, 5% and 10%, respectively.

Appendix 4 Sources of annual household cash income in the study districts (NRs)

Sources of income		Agriculture	Salaried job	Business	Remittance	Over all	P- value
Chitwan	Average income	26,945	74,394	20,910	59,846	81,988	0.05**
	Standard deviation	29,202	41,487	15,557	47,647	55,918	
	Frequency	60	30	14	13	60	
	Maximum	148,800	194,400	60,000	150,000	255,600	
	Minimum	600	21,600	6,000	15,000	7,560	
Siraha	Average income	12,653	55,767	16,105	52,365	54,662	0.03**
	Standard deviation	11,219	49,345	10,265	45,685	55,927	
	Frequency	45	25	11	10	60	
	Maximum	50,000	19,7100	36,360	125,000	225,600	
	Minimum	3,200	5,400	3,600	8,900	3,600	
Kailali	Average income	19,596	47,381	13,524	70,000	47,723	0.02**
	Standard deviation	18,028	35,951	11,793	17,677	41,042	
	Frequency	58	26	17	2	60	
	Maximum	40,700	162,000	48,000	80,000	165,251	
	Minimum	1,425	7,020	4,800	70,000	3,486	
Overall	Average	20,384	59,974	16,662	87,280	61,458	0.000***
	Standard deviation	22,178	43,520	12,924	56,145	53,353	
	Frequency	163	81	42	25	180	
	Maximum	148,800	197,100	60,000	15,000	255,600	
	Minimum	600	5,400	3,600	150,000	3,550	
	P value	0.000	0.002	0.125	0.421	0.041	

Note: Figures in the parentheses indicate percentage, *** and ** indicate significance at 5% and 10%, respectively.

Appendix 5 Sources of income from agriculture sector

Details		Food grains	Rice seed	Wheat seed	Livestock	Others	P- value
Chitwan	Average income	13,084	28,774	6,145	71,795	12,556	0.02
	Standard deviation	8,459	26,798	5,396	49,176	15,687	
	Frequency	26	54	41	46	13	
	Maximum	32,000	140,541	27,111	194,400	60,000	
	Minimum	1,500	4,240	541	7,200	500	
Siraha	Average income	8,334	10,819	3,199	3,112	12,039	0.000
	Standard deviation	7,115	8,869	2,937	2,479	11,883	
	Frequency	15	30	18	19	32	
	Maximum	22,800	43,030	10,218	10,000	50,000	
	Minimum	500	432	402	200	1,500	
Kailali	Average income	12,719	20,836	15,800	5,590	12,340	0.001
	Standard deviation	10,284	14,881	10,511	8,589	15,749	
	Frequency	35	32	21	42	37	
	Maximum	39,060	63,785	37,776	42,400	68,500	
	Minimum	2,280	5,087	2,959	850	1,249	
Overall	Average income	11,978	21,941	8,643	13,147	12,356	0.12
	Standard deviation	9,197	21,564	8,705	22,231	11,254	
	Frequency	76	116	80	107	82	
	Maximum	39,060	140,541	37,776	194,400	60,000	
	Minimum	500	432	402	200	500	
	P-value	0.004	0.001	0.000	0.02	0.142	

Appendix 6 Annual calendar for production and marketing of rice seed in the study area

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
S	S	S	S	S	M	P	I	I	I	H	C

Note: P = Planting, I= Intercultural operation, H = Harvesting, C= Seed collection from household, S = Storage of seed, M = Seed marketing

Appendix 7 Indicators and scores used to assess the capacity of CBSPOs

1. Participation

Sub-indicators	Scores			
	1	2	3	4
1.1 Participation of women	<10% women members in the organization	11-25% women members in the organization	26-50% women members in the organization	Women in the executive committee
1.2 Participation of poor (support strategies to poor)	No system	System exists but not operational plan to support	Special consideration for poor in credit or timely payment	Special considering for poor in the payment and credit both
1.3 General assembly (Annual meeting of CBSPOs)	Not held	Held but not regular	Regular but same members in the executive committee from the beginning	Held regular, and some members changed
4.5 Sub-committee	Not formed	Formed but not functional (no meeting within a year)	At least one sub-committee functional (≥2 meetings in a year)	At least two committees functional
1.5 Entry of new members	No system for entry of new members (only founder members exist)	System exists but no members entered in the organization	New people entered in the organization without equal share	New people entered in the organization with the provision of equal share

5 Business plan and its implementation

Sub-indicators	Scores			
	1	2	3	4
2.1 Role clarity in the business plan	Not available	Available in draft form but operational plan not developed	Operational plan developed in terms of activities and their time of implementation	Detail operational plan and roles specified

Business plan…….

Sub-indicators	Scores			
	1	2	3	4
2.2 Market research	Consultation is not done with stakeholders	Consult with local farmers	Consultation local farmers and local agrovets	Consultation with farmers, local and distant agrovets
2.3 Product diversification	Seed production of only one crop	Seed production of two or more crops	Two or more crops and inclusion of local varieties	Sell two or more crops seed and other inputs
2.4 Seed quality assurance measures	Simple bagging but no tagging	Seed packaging in branded bags but no tagging	Seed packaging in branded bags, use of tagging for <50% seed	Seed packaging in branded bags for >50% seed
2.5 Publicity of products	No publicity	Sending letter to organization	Sending letter and demonstration of seed in agri-fair	Publicity through FM radio

6 Incentive system

Sub-indicators	Score			
	1	2	3	4
3.1 Share collection from members in the organization	No system of collecting share	<50% of the members	50-75% of the members	>75% of the members
3.2 Incentive to executives	All voluntarily	Occasional basis only to chairperson	Occasional basis both chairperson and executives	Defined norms to pay chairperson and executives
3.3 Incentives to growers	No system for providing incentive to seed growers	Technical facilitation or subsidy on fertilizer/seed exists	Technical facilitation and subsidy exist but not crop insurance	Technical facilitation, subsidy and crop insurance
3.4 Information management	Written documents do not exist	Very raw, unclear and poor record keeping system	Draft type of simple record keeping system	Good record keeping system using ledger books
3.5 Common property management	No system for the use of common	System exists but not in function	Mobilized based on rotation	Mobilized based on payment to the

	property			organization

7 Linkage with service providers

Sub-indicators	Scores			
	1	**2**	**3**	**4**
4.1 Linkage of CBSPOs with agricultural stations (NARC) for source seeds	No linkage	Poor linkage with some communication	Visit to NARC station and source seed received	Two way visits and source seed received
4.2 Linkage of CBSPOs with seed testing laboratory	No linkage	Poor linkage with some communication	Visit to seed laboratory and services received	Two way communication between seed laboratory and CBSPOs
4.3 Linkage of CBSPOs with VDC	No linkage	Poor linkage with some communication	Visit VDCs and formal communication exist	Resource tapping from the organization
4.4 Linkage of CBSPOs government bank	No linkage	Poor linkage with some communication	Visit bank and formal communication exist	Resource tapping from the organization
4.5 Linkage of CBSPOs with DADOs	No linkage	Poor linkage with some communication	Visit DADOs and formal communication exist	Good linkage (received training or other sources)

Appendix 8 Cash and physical structures of CBSPOs across the study area

Districts	CBSPOs	Cash (NRs)	Grading machine	Storage house	Drying floor
Kailali	Krisak	110,000	Yes	Yes	No
	Kisan	41,000	No	No	No
	Sayapatri	55,000	No	Yes	No
	Kalika	42,000	No	No	No
Siraha	Fulbari	51,000	No	No	No
	Sagarmatha	33,000	No	No	No
	Janadibya	35,000	No	No	No
	Sampaid	15,000	No	No	No
Chitwan	Unnat	1,800,000	Yes	Yes	Yes
	Shreeram	1,000,000	Yes	Yes	Yes
	Pragati	280,000	Yes	Yes	Yes
	Bijbridhi	1,200,000	Yes	Yes	Yes

Appendix 9 Rice seed sold by CBSPOs to different actors in 2010

Districts	CBSPs name	Seed sold to different actors (%)		
		Agrovet	DADOs/NGOs	Farmers
Kailali	Krisak	-	60	40
	Kisan	-	60	40
	Sayapatri	20	50	30
	Kalika	-	50	50
Siraha	Fulbari	-	60	40
	Sagarmatha	40	40	20
	Janadibya	40	50	10
	Sampaid	-	60	40
Chitwan	Unnat	94	2	4
	Shreeram	95	1	4
	Pragati	93	3	4
	Bijbridhi	90	5	5

Appendix 10 Questionnaire used in the study

A) Household survey for seed producers

1. General information Questionnaire number……. ☐

Respondent::……..	Household head …….
Ethnicity: ☐ Dalit ☐ Janajati ☐ Others	District……..VDC……..
Date of survey (yy/mm/dd)……..	Ward…no…….Village……

2. Information about family

Relation with respondent	Male/ Female	Age	Education	Major occupation and income per month (NRs)			
				Major occupation	Income	Other income source	Income from other sources
Respondent							
Household head							

Note for the interviewer: Education indicates formal schooling years; Major occupation: 1 = salary job /pension within Nepal, 2 = Remittance, 3 = labor, 4 = farming (Income from farming is not necessary to fill up here as it will be calculated separately later on)

3. Land profile (kattha) and other assets

Land holdings	Irrigated	Un-irrigated
Total land owned by household		
Total cultivated owned by household		
Land rented out by household		
Land rented in by households		

1Kattha = 333 m^2

Roof type	☐ Thatched	☐ Tiles/GI sheet	☐ Concrete
Availability of tractor	☐ Own	☐ Rented	☐ None

Sources of irrigation

☐ Canal	☐ Well	☐ Tube-well (boring)
☐ Treadle pump	☐ Pond	☐

4. Livestock ownership

Type	Cow	Ox	Buffalo	Goat	Sheep	Pig	Poultry/duck	Pigeon	Others
Young									
Adult									

5. Annual household income (NRs) from livestock

Animals	Milk			Meat			Live animal		
	Product (kg)	Sale (kg)	Income (NRs)	Product (kg)	Sale (kg)	Income (NRs)	Product (no.)	Sale (no.)	Income (NRs)
Cow/ox									
He buffalo/she buffalo									
Goat/sheep									
Pig									
Chicken/Duck									
Pigeon									
Others									

6. Annual household income (NRs) from other sources

Sources	Unit	Total	Production (kg)	Sale (kg)	Income (NRs)
Vegetable	Kattha				
Fish	Kattha				
Bee	No of hives				
Nursery	Kattha				
Fruit	Kattha				
Cereals	Kattha				
Legumes	Kattha				
NTFP	Kattha				
Others					

7. For how many months is your home grown cereals sufficient for your households?……months

8. Relation to CBSPOs

What is your position in the institution?	☐ Chairperson ☐ Vice chairperson ☐ Secretary ☐ Joint secretary ☐ Treasure ☐ Member
What are the benefits being involved in CBSPO	☐ Source seed ☐ Credit ☐ Training ☐ Easy ☐ for marketing
When did you become the member of this institution?	☐ since establishment ☐ One year before ☐ less than one year
How frequently do you participate in the meeting?	☐ Always ☐ Sometimes ☐ Rarely ☐ Never
Who does participate in the major decision making of your institution?	☐ Chairperson ☐ Executive committee ☐ General assembly ☐ Others

9. Empowerment

Do you know the objective of your institution?	☐ Yes ☐ Little ☐ No

Had you taken any training before participating in the CBSP,

☐ Yes ☐ No

if yes please mention name and duration

Name	Duration (days)	Area
		1 2 3 4
		1 2 3 4
		1 2 3 4

Have you got any training after involving in the CBSPOs,

☐ Yes ☐ No

If yes, please mentions name and duration

Name	Duration (days)	Area
		1 2 3 4
		1 2 3 4
		1 2 3 4
		1 2 3 4

Note: Area; 1= Seed production, 2= Seed quality maintenance, 3= Marketing, 4= Acoount

Have you heard about different category of seed? ☐ Yes ☐ No, If yes, what are they?

Breeder	☐ Yes	☐ No	Foundation	☐ Yes	☐ No
Certified	☐ Yes	☐ No	Truthful label	☐ Yes	☐ No

Do you remove unwanted /diseased plants from seed production plots? ☐ Yes ☐ No

If yes, who involve for this rouging (tick as appropriate)

	Who			
	Family	CBSPO	Gov. lab	Others

10. Finance

Do you regularly deposit money monthly in your CBSPO? ☐ Yes ☐ No

If yes, what are the schemes and how much you deposit under those schemes?

	☐ Monthly	☐ Half yearly	☐ Yearly	☐ Others
NRs				

Have you deposited shares at your CBSPO? ☐ Yes ☐ No

If yes, please tell me the total amount until now NRs……..; If no, what could be reasons behind it?

☐ I cannot afford it	☐ I am not convinced with management
☐ I can invest if institution demands	☐ Others if any……

Have you taken loan from any institution /individual? ☐ Yes ☐ No

If yes, please mention

Purpose of loan	From whom?	Annual interest rate (%)			Remark
		Monthly	Half yearly	Annually	

11. Farm gate price of seed and grain (NRs/kg) at wholesale rate basis

Price (NRs)	Within one month of crop harvest		At the time of sowing seed		Remarks
	Seed	Grain	Seed	Grain	

Note: If price differs by varieties, please mention in the remarks

12. Cost benefit analysis of rice seed production)

Materials	Unit	Total quantity	Total price
Seed			
Fertilizer			
Pesticides			
Sub-total			
Labor			
Land preparation			
Planting			
Fertilizer application			
Pesticide application			
Weeding			
Harvesting			
Sub-total			
Total variable cost			
Fixed cost			
Land rent			
Total cost			
Gross revenue			
From seed			
From by product			
Total gross income			
Net income			

13. Production and sale situation 2010/11

Crops	Variety	Area (kattha)	Production (kg)	Sold to CBSPOs (kg)	Sold outside (Kg)
Rice	1				
Rice	2				
Rice	3				
Rice	Total				

14. If seed sold outside the institutions why do you sell outside?

☐ Higher price ☐ To meet immediate needs of the households

☐ CBSP does not guarantee timely ☐ Difficult to storage due to inappropriate housing structure

☐ Due to pest problem in storage ☐ Others

15. Fertilizer management in rice seed production (kg/kattha)

	FYM	DAP	Urea	Potash	Others
Amount					
Rate (NRs/kg)					

How do you apply urea in the rice field? 1) Only at the time of planting; 2) split doze

16. Use of soil conservation practices in rice

Practices	Heard	Adopted	Which crops
Zero tillage	☐ Yes ☐ No	☐ Yes ☐ No	
Improved composting/FYM	☐ Yes ☐ No	☐ Yes ☐ No	
Legume biomass incorporation	☐ Yes ☐ No	☐ Yes ☐ No	
Seed priming	☐ Yes ☐ No	☐ Yes ☐ No	
System of Rice Intensification (SRI)	☐ Yes ☐ No	☐ Yes ☐ No	

Do you think that adoption of any of the following practices will improve your soil fertility?			
Zero tillage	☐ Yes	☐ No	☐ I don't know
Improved composting/FYM	☐ Yes	☐ No	☐ I don't know
Legume biomass incorporation	☐ Yes	☐ No	☐ I don't know
Seed priming	☐ Yes	☐ No	☐ I don't know
System of Rice Intensification	☐ Yes	☐ No	☐ I don't know

B: Household survey for seed consumers

1. General information Questionnaire number…….

Respondent::……..	Household head …….
Ethnicity: ☐ Dalit ☐ Janajati ☐ Others	District……..VDC……..

Date of survey (yy/mm/dd)……..	Ward…no…….Village……

2. Information about family

Relation with respondent	Male/ Female	Age	Education	Major occupation and income per month (NRs)			
				Major occupation	Income	Other income source	Income from other sources
Respondent							
Household head							

Note for the interviewer: Education indicates years of formal schooling; Major occupation: 1 = salary job /pension within Nepal; 2= Remittance; 3 = labor; 4 = farming (Income from farming is not necessary to fill up here as it will be calculated separately later on)

Land profile (kattha) and other assets:

Land holdings	Irrigated	Un-irrigated
Total land owned by household		
Total cultivated owned by household		
Land rented out by household		
Land rented in by households		

1Kattha = 333 m^2

Roof type	☐ Thatched	☐ Tiles/GI sheet	☐ Concrete
Availability of tractor	☐ Own	☐ Rented	☐ None

Sources of irrigation

☐ Canal	☐ Well	☐ Tube-well (boring)
☐ Treadle pump	☐ Pond	☐

3. Livestock ownership

Type	Cow	Ox	He Buffalo	She buffalo	Goat	Sheep	Pig	Poultry/duck	Pigeon	Others
Young										
Adult										

4. Annual household income (NRs) from livestock

Animals	Milk			Meat			Live animal		
	Product (kg)	Sale (kg)	Income (Rs)	Product (kg)	Sale (kg)	Income (Rs)	Product (no.)	Sale (no.)	Income (Rs)
Cow/ox									
He									

buffalo/she buffalo									
Goat/sheep									
Pig									
Chicken/Duck									
Pigeon									
Others									

6. Annual household income (NRs) from other sources

Sources	Unit	Total	Production (kg)	Sale (kg)	Income (Rs)
Vegetable	Kattha				
Fish	Kattha				
Bee	No of hives				
Nursery	Kattha				
Fruit	Kattha				
Cereals	Kattha				
Legumes	Kattha				
NTFP	Kattha				
Others					

7. For how many months is your home grown cereals sufficient for your households?…….months

8. Please mention the crop varieties (up to three) you planted in 2067/068 and their characteristics

Crops	Varieties (area kattha)	Desirable characteristics	Undesirable characteristics
Rice1			
Rice2			
Rice3			

9. What are the main sources of seeds you use?

Crops	Sources				
	Agrovets	CBSPOs	DADOs/NARC	Neighboring farmers	Others
Rice					
Wheat					
Maize					
Lentil					
Mungbean					

Note: Rank in 1 to 5, where 1 is the most important

10. Institutional service

Are you involved in any institutions?	☐ Yes	☐ No

If yes, please mention

Name of the institution/group	Your responsibility/position

11. What are the organizations/projects working in your area?

Organizations' name	Main working area	Have you benefitted from those programs? If yes, how?

Working area: Agriculture, Saving credit, Social mobilization, etc

12. What the major sources of getting information about agriculture? (tick as appropriate)

Source	Access	Source	Access
Newspaper	1 2 3	Television	1 2 3
FM Radio	1 2 3	Agriculture service center	1 2 3
Agrovets	1 2 3	Others	1 2 3
	1 2 3		1 2 3

Frequency: 1= always; 2= Sometimes; 3=Rarely; 4= Never

C. Questionnaire for institutional level (CBSPOs) survey

1. General Information

CBSP Name:…….	Q.N……..
District:…… VDC…….	Village…….
Type of the organization: Group Cooperative	
Date of establishment: …….. ……..	

2. Member composition in your organization

General members	Gender		Ethnicity			Origin	
	Female	Male	Dalit	Janjati	Others	Tarain	Hill migrant
Total							
Involved in seed production							
Not involved in seed production							

Has the institution developed its constitution?	☐ Yes	☐ No

3. Composition of Executive Committee

Current (2011)			
Positions	Name	Age	Education
Chairperson			

Vice-chairperson			
Secretary			
Joint secretary			
Treasure			

4. Institutional activities

Do you have sub-committees within your institution?	☐ Yes	☐ No

If yes, please tick as appropriate

Sub-committees	Very active	Active	Inactive
Technical			
Marketing			
Account			

What are the sources of income of your institutions?

☐ seed production ☐ vegetable production

☐ saving credit ☐ Others

☐ ☐

What types of meetings do the institution organizes and who participates on these meetings?

Types of meetings	Executive committee	General members	
1) Monthly			

5. Capacity building

Do the members in the executive committee have taken any training?	☐ Yes	☐ No

If yes, please tick as appropriate

Name	Status	
General seed production	☐ Yes	☐ No
Marketing	☐ Yes	☐ No
Business plan	☐ Yes	☐ No
Account keeping	☐ Yes	☐ No
Leadership	☐ Yes	☐ No

6. Marketing

How do you target seed production/sale?	☐ last year experience	☐ Source seed available
	☐ Information from DADO	☐ Others

Does the institution prepare business plan of seed production and marketing?	☐ Yes	☐ No

Plans	Yes	No	Remarks

Production	☐ Yes	☐ No	
Marketing	☐ Yes	☐ No	

Two years records of seed sell

Crop	Year	Area planted (ha)	Seed collected by CBSP (t)	Seed collected just after harvest (t)	Seed collected at the time of selling (t)	seed sold (t)	Main varieties (3)
Rice	2009/10						
	2010/11						
Others	2009/10						
	2010/11						

Who are the major buyers (tons of seed sold to different agencies in 2010/11)

% seed sold	DADOs	Agrovets	NGO/INGOs	Farmers	Others	Total	Districts coverage

What factors do you consider while deciding seed purchasing price from growers/members?

☐ Grain price of the crop	☐ Last years' experience	☐
☐	☐	☐

What factors do you consider while determining selling price?

☐ Cost of seed purchase	☐ Profit to the organization
☐ Price fixed by district seed coordination committee	☐
☐	☐

How do you sale the seed? ☐ Retail ☐ Wholesale ☐ Both

If both, could you please mention about the price

Price (NRs/kg)	Retail price	General whole sale price	Special discount to agrovets

7. Payment mechanism to the growers

Has your organization developed rules for payment to its growers?	☐ Yes	☐ No

If yes, what % of sold amount is paid to different categories of farmers?

	Poor household	Medium household
During harvesting		
After seed sale		

8. What types of advertisement/promotional strategies you follow in seed marketing?

☐ FM radio	☐ local newsletters
☐ seed display at public form	☐ sending letters to DADOs

☐ Agrovets, NGOs	☐

9. Value addition technique

Do the institution use packaged and labeled bag?	☐ Yes	☐ No	If yes, which crops?

% of seed	Packaging size (kg)						
	1-2	5	10	15	20	25	30

10. How much amount of money goes to institutional saving from per kg of seed sale?

11. Finance

Does the institution have bank account?	☐ Yes	☐ No

Has your institution taken loan from any institutions/individuals for seed production? Yes; no; if yes

Source	Amount	Annual interest rates (%)
CBSP members		
Bank		
Cooperative		
Land lord		
Others		

Do all the members deposit money regularly in your CBSP? ☐ Yes ☐ No

Saving rate (NRs/month): 1) When you started collecting first time…….; 2) Now……

12. Communication and networking

What types of information CBSP maintains?	☐ Meeting minutes	☐ Sales record
	☐ Loan and payment record	☐ None
What is the information sharing mechanism in your organization?	☐ Sharing verbally in monthly meeting	☐ Audit report in yearly basis
	☐ Sharing verbally after attending training/seminar	☐ Others

How frequently are you in contact with the following institutions?

DADO	1	2	3	DDC	1	2	3
VDC	1	2	3	Micro-finance	1	2	3
NARC centers	1	2	3	Agrovets	1	2	3

1 = Frequently; 2 = Sometimes; 3= Never

13. Assets of the institution

Materials	Total	Current value (NRs)	Source of fund	If you got in donation please mention	
				Name of organization or individual	Amount (cash or kind) with unit
Land (kattha)			1 2 3		
Storage room (No)			1 2 3		
Grader machine (No)			1 2 3		
Seed in storage(t)			1 2 3		
Cash in bank (NRs)			1 2 3		
Investment in other business			1 2 3		

Source: 1= CBSP's own fund; 2 = Rent; 3= Donation

Does the institution hire staff?	☐ Yes	☐ NO

If yes, please mention the names of the staff and some information about them

Name	Position	Education	Training name if taken?
			1 2 3 4
			1 2 3 4
			1 2 3 4

Area: 1= Technical, 2= Marketing; 3= Account; 4= Institutional development; 4= leadership

14. Source of income for the enterprise (2010/11)

Source	Annual income(NRs)	Source	Annual income(NRs)
Seed sale			
Membership fee			

15. Profitability analysis of CBSPOs in rice seed marketing

CBSPO name	Items	Cost	Items	Cost
	Volume of seed purchased		Labor cost	
	Value		Packaging cost	
	Moisture loss at processing (%)		Communication	
	Transportation cost		Rent of house	
	Processing cost		Revenue	
	Bagging cost		Gross profit	
	Tax			

16. Impacts of climate change and responses made by the community

Has flood and drought has affected in your CBSPEs? ☐ Yes ☐ No

If yes, please mentions the reasons?

☐ Total volume of seed transaction reduced	☐ Increased cost involved in storage	☐
☐	☐	☐

Has your organization developed any policy to safeguard growers from impacts of climate change?	☐ Yes	☐ No

If yes what are those policies?

Hazards	**Policy**
Flood	
Drought	

Are the current policies sufficient?	☐ **Yes**	☐ **No**
If not what kinds of policy is required		

Policy	Within CBSPs	Government

Please say any 3 important problems faced by your CBSPE

Area	**Problems**	**Importance**
Source seed		
Loan		
Institutional management		
Marketing		
Infrastructure		

Importance: 1= High; 2 = Medium; 3= Low

Appendix 11. Academic and professional profile of the author

1. Personal Information

Name:	Narayan Prasad KHANAL	
Permanent address:	Kerunga-1, Arghakhanchi, Nepal	
Email:	narayankhanal36@gmail.com	
Sex:	Male	
Date of birth:	January 8, 1976	
Nationality:	Nepali	
Marital Status:	Married	

2. Academic Background

Degree	Study area	Division (%)	Graduation	Institution
Ph. D.	Rural Economics	-	2013 September	IDEC, Hiroshima University, Japan
M.Sc. Ag.	Plant Pathology	First (83%)	2002 June	Institute of Agriculture and Animal Science (IAAS), Tribhuvan University (TU), Rampur, Chitwan, Nepal
B. Sc. Ag.	Horticulture	First (75.6%)	1999 May	IAAS, TU, Rampur, Chitwan, Nepal
I. Sc. Ag.	Agriculture	Second (64.9%)	1994 November	IAAS, TU, Rampur, Chitwan, Nepal
High School	Mathematics	First (64.8%)	1992 July	Shree Mahendra Bidhya Bodh Secondary School, Arghakhanchi, Nepal

3. Specialization

- Participatory research and development
- Agriculture, forestry and livestock based rural livelihoods
- Impact assessment, capacity building, partnership
- Sustainable development

List of projects designed and implemented in my leadership

A) "Participatory crop improvement in South Asia (2008-2010)", Research into use program, implemented through FORWARD in 8 Tarai districts of Nepal in partnership with National Agricultural Research Institutes and Center for Arid Zone Studies, University of Wales, UK

B) "Improving food security through dissemination of improved cereal and legumes varieties and promotion of community-based seed production system in central Tarai region of Nepal (2008-2010)" in partnership with National Agriculture Research and Development Fund, Nepal.

C) "Promoting legumes in hills and Tarai of Nepal (2004-2006)", in partnership with, Nepal

Agricultural Research Council, and International Crops Research Institute for the Semi Arid Tropics.

D) "Capacity building of local partners for implementing livelihood improvement activities in Dailekh district of Nepal (2004-2006)", in partnership with Helvetas Nepal

E) "Integrated management of rapeseed management in the far and mid-western development region of Nepal (2003-2006)", in partnership with National Agricultural Research and Development Fund and National Oilseed Research Program, Nepal.

F) "Promotion of integrated pest management approaches against fruit borer and viral diseases of tomato in mid-western development region of Nepal (2003-2007)", in mid and far-western development region, in partnership with National Agricultural Research and Development Fund

G) "Food security through strengthening local seed supply system and disseminating improved cereal crop varieties in mid-hills of Nepal (2000-2003)", in partnership with National Agricultural Research and Development Fund and National Grain Legumes Research Program, Nepal

4. Awards

- Japanese government scholarship to pursue Ph D (2010-2013) at IDEC, Hiroshima University, Japan
- Letter of Appreciation for taking lead role in releasing mungbean varieties in partnership between FORWARD, NARC and Bangor University, UK, in Nepal in 2006
- Research Assistantship award from soil health management project (CRSP), Cornell University, USA during Master degree
- Merit scholarship award during I. Sc. Ag. And B.Sc. Ag. Courses from TU, Nepal

5. Employment record

Employer	Period	Position	Responsibilities
Graduate School for International Development and Cooperation (IDEC), Hiroshima University, Japan	2012 Oct to Feb 2013	Teaching Assistant	Assist resource person in arranging the classrooms, delivering lectures, preparing teaching materials, and other logistics
Forum for Rural Welfare and Agricultural Reform for Development (FORWARD), Nepal	2006 July to 2010 September 2004 July to 2005 June 2003 January to 2004 June	Program Officer Sr. Program Officer Sr. Program Manager	Project design, implementation, monitoring, evaluation, reporting
IAAS/TU, Rampur, Chitwan	2002 July-2003 Dec	Research Associate	Data analysis and report writing
National Grain Legume Research Program, Rampur	2002 Aug -2003 Dec	Legume Expert (part time)	Management of participatory research

6. Language skills

- Good working knowledge on Nepali and English
- Can communicate a little bit on Hindi and Japanese

7. Publications

a) Journal Articles (Refereed)

Khanal, N.P. and Maharjan, K.L. (2013). Socio-economic determinants for the adoption of improved rice varieties in the tarai region of Nepal. *Journal of International Development and Cooperation*. Special Issue 19(4): 17-27.

Khanal, N.P. and Maharjan K.L. (2013). Technical efficiency of rice seed growers in the Tarai region of Nepal. *Journal of Rural Problem* 49 (1): 27-31.

Khanal, N.P. and Maharjan, K.L. (2013). Socio-economic factors influencing the adoption of soil conservation practices under rice-wheat system in the tarai region of Nepal. This article is in press in *International Journal of Sustainability*, CG Publisher.

Khanal, N.P. and Maharjan, K.L. (2013). Factors influencing farmers' behavior in selling rice seed in the market. This article is in press in the *journal Agriculture and Food Economics*, Springer.

Khanal, N.P., Maharjan, K.L. and Sapkota, A. (2012). Technical efficiency in wheat seed production: a case study from Tarai region of Nepal. *Journal of International Development and Cooperation* 19 (1): 41-50. http://ir.lib.hiroshima-u.ac.jp/metadb/up/kiyo/AN10482914/JIDC_19-1_41.pdf).

Joshi, K.D., Devkota, K.P., Harris, D., **Khanal, N.P**., Paudyal, B., Sapkota, A., and Witcombe, J.R. (2012). Participatory approaches rapidly improve household food security in Nepal and identify policy changes required for institutionalization. *Field Crops Research* 131:40-48.

Khanal N.P and Maharjan, K.L. (2010). Sustainability of community-based seed production enterprises in Nepal: Institutional issues. *Nepal Agriculture Research J.* 10: 33-40. ttp://pustakalaya.org/eserv.php?pid=Pustakalaya:3772&dsID=NARC2010_NepalAgricultureResearchJournalVol10.pdf

b) Review paper (Refereed)

Khanal, N.P., Maharjan, K.L. and Dangol, D. (2012). Soil conservation practices for sustainability of rice-wheat system in Nepal: A review. Journal of International Development and Cooperation, 18 (4): 11- 20. http://ir.lib.hiroshima-u.ac.jp/metadb/up/kiyo/AN10482914/JIDC_18-4_11.pdf.

c) Proceeding papers

Khanal, N.P., Gurung, G.B. and Tiwari, Y.N. (2007). Integrated nutrient management for sustaining rapeseed in Nepal. Procedinds of 25th National Outreach Research Conference, July 8-10, Kathmandu, Nepal. Nepal Agriculture Research Council, Khumaltar, Lalitpur, Nepal.

Khanal, N.P., Khanal, N.N., Gurung, G.B., Thapa, S., Gupta, K.P., Sherpa, L.T., Joshi, K.D., Harris, D., Kumar Rao, J.V.D.K., and Darai, R. (2006). Mungbean (Vigna radiata (L.) Wilczek) in cereal fallows: Experience of farmers' participatory research and development activities in foothills and

terai of Nepal. In: M.C. Kharkwal (ed), pages 11-21. Proceedings of 4th International Food Legumes Research Conference. ICAR, India.

Khanal, N.P., Khanal, N.N., Thapa, S., Gupta, K.P., Sherpa, L.T., Joshi, K.D., Harris, D., and Kumar Rao, J.V.D.K. (2006). Pages 10-17. Potential of Helicoverpa Nucleopolydrovirus for the management of chickpea pod borer in Nepal. Proceedings of the National Workshop on Permaculture and Organic Agriculture, 13-15 December, 2005 in Kathmandu, Nepal.

Grazway, D, Pandey, S., **Khanal, N.P.,** and Maharzan, R. (2005). Alternative pest control approaches: NPV for pod borer control and its uptake in Nepal. In: S. Pande, P.C. Stevension, R.K. Neupane and D. Grzywacz (eds.), pages 143-152. Policy and strategies for increasing income and food security through improved crop management of chickpea in rice fallows in Asia. Summary of a NARC-ICRISAT-NRI workshop, 17-18 November 2004, Kathmandu, Nepal. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Khanal N.P. (2004). Integrated management of foliar diseases of chickpea. In: R.K Neupane, NK Yadav and R. Darai eds., pages 25-30. Proceedings of the National winter crops workshop (grain legumes). National Grain Legumes Research Program, Rampur, Chitwan, Nepal.

Khanal, N. P., Shrestha, S.M., and Khattri.Chhetri, G.B. (2004). Integrated use of fungal antagonists, fungicides and micronutrients against chickpea wilt complex. Proceedings of the 25th National Winter Crops Workshop organized at Khumaltar, Lalitpur, Nepal from 8-10 March, 2003.

Khanal, N.P. and Khanal, N.N. (2004). Bridging the gap: Role responsibilities and approaches to scaling-up IPM of chickpea in Nepal. In: S. Pande, P.C. Stevension, R.K. Neupane and D. Grzywacz (eds.), pages 182-189. Policy and strategies for increasing income and food security through improved crop management of chickpea in rice fallows in Asia. Summary of a NARC-ICRISAT-NRI workshop, 17-18 November 2004, Kathmandu, Nepal. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Khanal, N.P. and Shrestha, S.M. (2003). Integrated management citrus root rot in the western hills of Nepal. In: Citrus decline management in the hills of Nepal. Compilation of research articles, Dhakal, D. D. and N.P. Khanal (eds.). Institute of Agricultural and Animal Science, Rampur, Chitwan, Nepal.

d) Policy documents and others

Gauchan D, Dahal, K. and Khanal, N.P. (2007). Gains of on-farm resource management project in enhancing livelihoods of landless communities in Nepal. Plan International, Kathmandu, Nepal.

Khanal, N.P., Khanal, N.N., Yadav, N.K., Darai, R., Joshi, S., Neupane, R.K., Sherpa, L.T., Thapa, S., Gupta, K., Neupane, R., Pokharel, D.N., Sah, R.P., Adhikari, B.N., Joshi, K.D., and Harris, D. (2006). A proposal for the release of Mungbean varieties NM94 and VC6372 (45-8-1): *Jointly Submitted by* FORWARD, National Grain Legumes Research Programme (NGLRP), and

CAZS-Natural Resources (CAZS-NR), University of Wales, Bangor, UK. http://www.cazs.bangor.ac.uk/ccstudio/Library/publications/ReleaseProposals/Mungbean.pdf.

8. Participation and presentation in conferences

Khanal, N.P. and Maharjan, K.L (2013). Socio-economic determinants for the adoption of soil conservation practices in the tarai region of Nepal. A paper presented in the 9th International conference on environmental, cultural, economic and social sustainability be held in International Conference Center, Hiroshima, Japan, 23-25 January, 2013.

Khanal, N.P. and Maharjan, K.L (2013). Households' behavior in selling rice seed in the market. A poster to be presented at the 11th International conference on dry land development: global climate change and its impacts on food and energy security, organized by dry land development commission (IDDC), at Beijing, China, 18-23 March, 2013.

Khanal, N.P. and Maharjan, K.L. (2012). Technical efficiency of rice seed growers in the tarai region of Nepal. A paper presented at 62th annual meeting of Association for Regional Agricultural and Forestry Economics at Osaka University of Economics, Japan, 19-21 October 2010.

Khanal, N.P. and Maharjan, K.L. (2012). Soil conservation practices in rice-based cropping system: a case study from tarai region of Nepal. A poster presented at a symposium entitled advanced education for environmental leader focusing on sustainable development in Asia and Africa at Nagoya University, Japan, 22 November, 2012.

Khanal, N.P. and Maharjan, K.L (2012). Conservation agricultural practices in rice-wheat system of Nepal. A poster presented in the 3rd international Conference entitled Conservation Agriculture and Sustainable Upland Livelihoods: innovation for, with and by farmers to adapt to local and global changes in the Southeast Asia, Organized by French Center for International Agricultural Research for Development (CIRAD) Northern Mountainous Agriculture and Forestry Institute (NOMAFSI), and University of Queensland (Australia) at Hanoi, Vietnam, 10-15 December, 2012.

Piya, L. and **N.P. Khanal**. 2012. Current situation of hydrological disasters and management policies in Nepal. A paper presented in the Summer Course entitled development within a low carbon world: preparing professionals for disaster risk reduction and climate change adaptation, jointly organized by Global Environmental Leader Program for designing low carbon society, Graduate School for International Development and Cooperation, Hiroshima University; The school of Urban and Regional Planning, The University of Philippines, Diliman; and Lyndon B. Johnson school of public affairs, The University of Texas, Austin, held in the Philippines.

Khanal, N.P. and Maharjan, K.L. (2011). Impact of climate change in seed production in Tarai region of Nepal. A paper presented in a symposium on climate change, food security and livelihoods, jointly organized by Hiroshima University and Institute of Agriculture and Animal Science at Rampur, Chitwan, Nepal, 23 November, 2011.

9. Training courses/workshops

- Summer course 2012 titled Development within a Low Carbon World: Preparing Professionals for Disaster Risk Management and Climate Change Adaptation, jointly organized by Global Environmental Leader Program for Designing Low Carbon Society, Graduate School for International Development and Cooperation; Hiroshima University's Center for Environmental Cooperation; The school of Urban and Regional Planning, The University of Philippines, Diliman; and Lyndon B. Johnson school of public affairs, The University of Texas, Austin, held in the Philippines from 6 to 16, 2012.
- Attended various environmental related lectures and courses (Environmental Cooperation Study-1 and 2; and Practical Seminar-1 and 2 under the program Global Environmental Leader Program for Designing Low Carbon Society, Graduate School for International Development and Cooperation, Hiroshima University from 2010 to 2013.
- Research method and data analysis training, organized by Institute for Social and Environmental Research, held in Chitwan, Nepal, in collaboration with the population studies center at the university of Michigan, USA, from 16-20 May, 2010
- Participatory data management and analysis, organized by Center for Arid Zone Studies, University of Wales, UK, held in Chitwan, Nepal, from 9-10 November, 2008
- Value chain study in agricultural crops, organized by FORWARD in Chitwan, Nepal, from 10-15 March, 2007
- Nuclear Polyhedrosis Virus production and usages and integrated disease management chickpea diseases, organized by International Crops Research Institute at Semi Arid Tropics (ICRISAT) in Hyderabad, India, from 18-27 January, 2005
- Helicoverpa Nuclear Polyhydrosis Virus production technology, organized by ICRISAT in Chitwan, from 16-18 February, 2004

10. Computer and analytical skills

- Microsoft word, excel and power point
- MSTATC, Arc GIS, STATA, MINITAB

11. Membership and Linkage

- Life member of Society of Agricultural Scientist (SAS), Nepal
- Associate Editor/Reviewer in Sustainability Journal
- Member of Sustainability Compmunity
- Member of Climate Change NGO network Nepal
- Member of Association of Regional Agriculture and Forestry Economics, Japan