ASSESSING THE BARRIERS TO ADOPTION OF CONSERVATION AGRICULTURE PRACTICES AMONG CHEPANG COMMUNITIES IN THE CENTRAL MID-HILLS OF NEPAL

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To Catherine Chan,
mother, mentor, and inspiration.

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ABSTRACT

Growing global populations and shifting climates have led to increasing demands on agricultural systems to produce greater yields through the more efficient use of natural resources. Conservation Agriculture (CA) practices, have been introduced to improve crop production and promote sustainable development. However, the long-term adoption of introduced CA has been variable and such practices have frequently been abandoned for traditional practices following the completion of agency-funded development projects. Elements contributing to long-term adoption include personal, social, cultural, and economic factors, and the ability to align introduced technology with the individual goals of farmers and agricultural communities. Nevertheless, reviews of CA studies revealed that there are few, if any, universal determining factors that consistently influence the adoption of new technologies and factors influencing local adoption vary due to differing socio-cultural and ecological conditions. This dissertation research studies the barriers to adoption of CA practices in Nepal through analysis at three levels: community, household, and individual. At the community level, a cognitive modeling approach was used to measure the gaps in perceptions of the farming system and introduced CA technologies between farming communities and researchers. To assess the household level, gender-based engagement in decision-making and distribution of agricultural labor was measured to determine household dynamics and identify possible obstacles to CA implementation. Finally, to consider the barriers to adoption at the individual level, farmer socio-economic characteristics are assessed to determine the key factors involved in decisions of adoption or non-adoption. Each of these results contributes to greater understanding of the local cultural and environmental contexts in terms of long-term CA implementation.

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CHAPTER 1. INTRODUCTION

Growing global populations and shifting climates have led to increasing demands on agricultural systems to produce greater yields through the more efficient use of natural resources. Concerns over sustainable food production and food security are exacerbated in rural, mountainous regions where a higher susceptibility to soil erosion is present (Beniston 2003) and access to information regarding improved agriculture technologies is limited. There are more than 500 million smallholder farms worldwide (<2 ha), consisting of households struggling to produce sufficient crop yields, have limited access to resources for agricultural inputs, and face the constant risk of food insecurity (IFAD 2011). As a result, considerable research and international development resources have focused on promoting the long-term productive capacity of smallholder farming communities and improving food security. In response to these issues, many agricultural technologies, such as conservation agriculture (CA) practices, have been proposed to improve crop production systems and promote sustainable development. However, the long-term adoption of introduced agricultural practices has been variable and historical evidence shows that communities often revert to traditional practices following the completion of agency-funded development projects (Bunch 1999, Cochran 2003, Yadav 1987, de Graaf et al. 2008). Numerous studies have attempted to identify factors as broad as education level, gender, economic status, knowledge of natural resources, and social responsibility as global indicators of adoption likelihood. While these factors have been identified as important contributors towards motivation for learning new farming practices, they do not necessarily determine long-term adoption (Kessler 2006, Knowler & Bradshaw 2007). Furthermore, elements contributing to adoption include a combination of personal, social, cultural, and economic factors, and the ability to align introduced technologies with the individual goals of farmers and agricultural communities (Pannell et al. 2006). Nevertheless, reviews of conservation agriculture studies revealed that determining factors influencing the adoption of new technologies are highly contextual and tend to vary due to differing local and ecological conditions (Knowler & Bradshaw 2007, de Graaf et al. 2008). Studies have shown that an interdisciplinary approach with considerations towards social, economic, cultural, institutional, biophysical, and technical factors is critical for sustained use of introduced technologies beyond the scope of project implementation (McDonald & Brown 2000). Thus, it is crucial to approach the introduction of agricultural development programs from a bottom-up perspective, developing a greater understanding of the complex drivers of farmer decision-making, and encouraging a community and stakeholder participatory approach in order to design project goals and objectives that serve the interests of multiple farm stakeholder groups (Chambers 1994; Pretty 1995). Moreover, when promoting CA in international development, it is necessary to assess whether the promotion of new technologies are locally appropriate and how different perspectives regarding agricultural beliefs and expected outcomes can be aligned to increase the success of international agriculture development.

This dissertation research identifies the barriers to adoption of conservation agriculture practices through a multi-dimensional analysis at three levels: community, household, and individual. Using a nested research approach, different research methods were applied to address relevant adoption dynamics at these three levels (Figure 1.1). Chapter 2 explores community understanding of the agricultural system through the use of a cognitive modeling approach to measure the gaps in perceptions of the farming system and introduced CA technologies between farming communities and researchers. Chapter 3 assesses agricultural decision-making at the household level, specifically measuring the distribution of household and agronomic labor and gender-based engagement in decision-making to determine household dynamics and identify possible obstacles to CA implementation. Finally, in Chapter 4, the barriers to adoption are considered at the individual level where personal socio-economic characteristics and resource availability are evaluated to determine factors that promote or impede adoption and non-adoption. Overall, this work aims to contribute to the growing field of knowledge relating to farmer perceptions and decision-making through developing a greater understanding of the farmer perspective and the barriers to adoption of conservation agriculture practices.

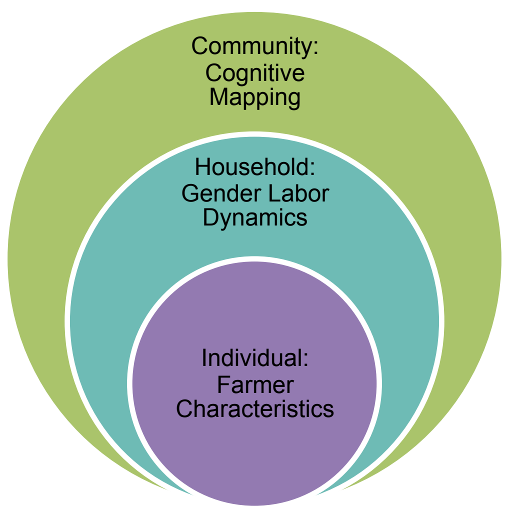

Figure 1.1. Multi-dimensional Nested Research Approach

1.1 Study area: Central Mid-hills, Nepal

This study was conducted in three rural communities in the central mid-hill region of Nepal engaged in the Sustainable Management of Agro-ecological Resources for Tribal Societies

(SMARTS) Project. This is part of the USAID-funded Feed the Future Innovation Lab for Collaborative Research on Sustainable Agriculture and Natural Resource Management. The overarching goals of this project are to study the feasibility of implementing Conservation Agriculture Production Systems (CAPS) from both an agronomic and socio-economic perspective in lesser-developed countries. The study communities were selected to take part in the study in consultation with a local NGO who identified these communities as highly impoverished and at great risk of food insecurity due to their marginal agricultural lands, small landholdings, and potential for malnutrition. The communities included in this study are characterized by smallholder subsistence farming households, with typically less than 1 ha of arable land, and limited opportunities available for income generation.

The central mid-hill region comprises 42% of the total territory of Nepal. More than one third of the country's total agricultural land is located in this region, feeding 44% of the country's population of 29.8 million (Thapa & Paudel 2002). For these reasons, it has become a major area of focus for reducing food security vulnerabilities and implementing agricultural adaptations for climate change. Much of the region's agricultural production is from smallholder subsistence farmers using traditional continuous cultivation methods of terracing, plowing with draft power, and utilizing a sole cropping agricultural system. In recent years, however, growing populations and deteriorating agricultural land has led to an increased need for improved agricultural technologies to increase soil and water conservation as well as crop yields. Local NGOs and local university researchers have been working in these communities to introduce improved cultivation methods, however, there exists a gap in the agricultural specialists' understanding of the farmer's motivation and willingness to adopt new practices (Kerkhoff & Sharma 2006, Khadka 2010).

The study villages (Figure 1.2) represent communities highly reliant on agriculture production with limited resources for income generation available. The residents of the villages are predominantly from the *Chepang* ethnic group. The selected villages included *Thumka*, in Gorkha District, *Hyakrang*, in Dhading District, and *Khola Gaun*, in Tanahun District. In these areas, farming systems are maize and rice based, using predominantly local crop varieties. Additionally, farmers have been forced to abandon traditional shifting cultivation practices due to scarcity of land and policy shifts that have promoted reforestation through restricting cultivation of hillsides. Instead, they have adopted continuous cultivation of the same land year after year, following conventional tillage practices (full plowing twice before sowing), using relatively low inputs of fertilizer, and leaving the land fallow and exposed in the dry, winter season. Such practices tend to degrade land quality and result in decreasing crop yields over time.

The characteristics of the villages in the study site, as rural, subsistence farmers engaged in cultivating marginalized land, typify many regions that have become priority areas for international agriculture development. Recent studies have shown that conservation agriculture practices have been successful in sustaining productivity in lesser-developed countries that traditionally use “slash and burn” techniques. Due to population pressures, shifting cultivation and slash and burn are no longer common practices in the study area. Nevertheless, the CA practices of minimum tillage and the use of cover crops could potentially help mitigate soil nutrient depletion, land degradation, and increase yields (Hobbs et al. 2008).

1.2 Study community: The *Chepang*

The *Chepang* are an indigenous tribe to Nepal and have been characterized as one of the country’s most marginalized communities in terms of poverty and geographic isolation (Bhattarai 1995). Of Nepal’s 59 indigenous nationalities, the *Chepang* have been ranked as the second most marginalized by the Nepal Federation of Indigenous Nationalities (Chepang 2014). Historically, the *Chepang* were a semi-nomadic, foraging people (Chhetri et al. 1997); however, Nepal’s rapidly increasing population over the past 60 years and stricter forest management policies have limited land access and pressured the *Chepang* into settling into subsistence farming communities (Upreti and Adhikari 2006). As of 2000, the population of *Chepang* was approximately 52,000 (0.23% of Nepal’s total population, Luni et al. 2012), with most residing in the hills of central Nepal in the districts of Dhading, Chitwan, and Gorkha (CBS 2001). Some of the Chepang population also resides in Lamjung and Tanahun districts (Sharma 2011).

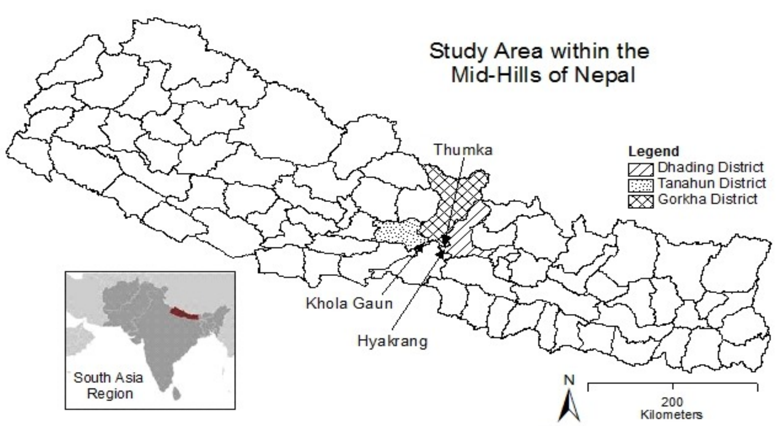

Figure 1.2. Map of Study Area, Central Mid-hills, Nepal.

Culturally, the *Chepang* are a patriarchal society with male heads of household and with land ownership (formal or informal) being passed down to sons only. Nevertheless, household hierarchy structures indicate that advanced age is also well regarded and respected in the household, regardless of gender. A typical household hierarchy structure would be the male head of household, followed by the female head of household, then by sons in birth order and finally by daughters and wives of sons living in the household. If elder sons or other adult male family members are living in the home, they may supersede the female head of household in the hierarchy. In terms of household and agricultural decision-making the male and female heads of household will often discuss issue together yet, it is often the male who makes the final decision. Both household and agricultural tasks are typically divided based on traditional gender roles, however, these roles are not strictly adhered to and when someone is needed to perform a task, it is often completed without regard to gender. For example, if the female head of household is working on the farm, the male head of household will often step in to prepare the meal despite this being a typically “female“ task. Nevertheless, women still perform the bulk of both agricultural and household duties. Offsetting this is the availability of off-farm wage earning opportunities for men, often construction or other manual labor. The primary opportunities for women are exchange agricultural labor, which is a barter system and not a direct wage-earning opportunity. Such differences in wage-earning potential between genders may have implications for the willingness to adopt new agricultural practices. Additionally, some income generating opportunities exist for producing and selling livestock and remittance from household members working away from the village; though, since these activities require some form of capital, opportunities such as these are generally available only to households with higher socio-economic status (Halbrendt 2014).

Access to education in *Chepang* villages is exceedingly limited. Occasionally, primary schools are located within walking distance of the village; however, the government has faced difficulties in consistently staffing schools at such remote locations. Over 25% of students are required to walk more than one hour to the nearest primary school, with typically further distances to secondary schools (Tryndyuk 2013). As a result, many *Chepang* have few years of formal education experience. Cultural traditions, illiteracy of parents, insufficient school facilities, distance to schools, and poverty have all been cited as contributors to school dropout rates. Moreover, girls face the added pressures of higher expectations of contributing to household tasks. Specifically, girls between the ages of 10-14 are expected to work twice as many hours as boys of the same age (Tryndyuk 2013). This leads to lower attendance and higher eventual dropout rates of girls in school. A tradition of girls marrying at a young age also contributes to their reduced enrollment in school.

In addition to reduced access to education for girls, Nepali women face a disproportionate burden of poverty. Though there are variations across socio-economic sectors, Nepali women in general have reduced access to food and nutrition, higher labor demands, and limited access to economic opportunities (Bhadra and Shah 2007). The adult literacy rates for women are only 65.7% that of men. Moreover, young age at the time of marriage, particularly for girls, and low access to contraceptives (49.7% of the female population) and family planning put women at a further social disadvantage (UNICEF 2013). Such development indicators are expected to be even lower for indigenous populations such as the *Chepang* (Piya et al. 2011).

The *Chepang* were traditionally dependent on forest products for subsistence (Chepang 2014). As a transition away from foraging, the *Chepang* first used shifting cultivation as a means for providing a supplemental food source. Approximately 120 years ago, the Chepang became semi-nomadic in that they would cultivate a cleared piece of land in the forest for a few years until the soil became depleted, then they would move to another area, cultivate that land, and so on, forming a multi-year rotation. This shifting cultivation approach was adapted to include terracing approximately 80 years ago (Gurung 1990). With increased regulation of land through acts such as the Private Forest Nationalization Act of 1957 and the more recent Forest Act of 1993, when it became illegal to hunt or cultivate crops in the forest, the traditional system was no longer possible and permanent settlements were established (Luni et al. 2012). It is important to note, however, that the settlement onto marginal lands is a result of not only population growth and policy change, but also of a general exclusion of the *Chepang* and other ethnic groups participating in shifting cultivation from the formally recognized land management system. As traditional shifting cultivation occurred on land that is now classified as forest, no documented proof has been granted recognizing historical agricultural use of the land (Sharma 2011). This has resulted in lower land availability per household, shortage of land for cultivation purposes, marginal landholdings, and higher risk of food insecurity. Moreover, there has been a loss of indigenous cultivation knowledge as the established shifting cultivation practices have been replaced with the less familiar continuous cultivation approach. The long history of *Chepang* shifting cultivation signifies that the traditional agro-forestry approaches were ecologically sound, allowing for maintenance of soil fertility through forest biomass production and fallow cycles, and reduced erosion and risk of landslides through selection cutting of trees and natural forest regeneration processes (Sharma 2011). In contrast, the imposed land restrictions and subsequent implementation of continuous cultivation has constrained the productivity of the land in terms of soil fertility and resilience to degradation. The impacts of this are compounded when we consider the economic marginalization of the *Chepang* and their low capacity to supplement the agricultural system with inputs of fertilizer and improved seed varieties.

As with many smallholder, subsistence farming communities, food security is of great concern in the *Chepang* villages. Members of the study communities expressed that there is food scarcity for approximately six months of the year, primarily during the dry winter season (Halbrendt 2014). Lacking consistent opportunities for off-farm wage earning, and facing the limitations of cultivating highly degradable, marginal land, improving agricultural yields and practices is an imperative. Nevertheless, solutions to address these needs must be culturally, environmentally, and economically appropriate. The dimensions addressed in the Nested Research Approach (Figure 1.1) seek to explore the *Chepang* farmer perspective in terms of the agricultural needs and priorities of an indigenous, marginalized community, as well as consider the complexities of the local social, cultural, and gender contexts.

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Chapter 2. Differences in farmer and expert beliefs and the perceived impacts of conservation agriculture

2.1 Abstract

Departing from the traditional agricultural model of input-heavy, intensive agriculture via the use of agrochemicals and irrigated water, many international development projects have started to promote conservation agriculture in developing countries. However, relying solely on technical expertise, largely generated outside the rural communities in which they are applied, often does not consider whether local ecological and culturally influenced beliefs are consistent with the technologies being promoted for adoption. We suggest these disconnects can be linked to differing ‘mental models’ of scientific experts and rural agricultural communities regarding the nature of farming dynamics and predicted impacts of introduced farming practices. Using an agricultural development project in Nepal as a case study, this research seeks to understand the relationship between trends in expert and rural farmer reasoning and predictions regarding the outcomes associated with development technology based on these beliefs. Further, we seek to compare these mental model-based differences with local environmental conditions (using soil measurements) and agricultural outcomes in terms of farm production (i.e. yield). While researchers’ mental models predicted that minimum tillage would improve yield, mental models from two of the three villages predicted that yield would decrease. Local soil and yield measurements support the farmers’ mental model predictions. Our results indicated that conservation agriculture techniques should not be applied universally, development practitioners should engage in a two-way learning with local communities to benefit from locally situated knowledge.

2.2 Introduction

With rising populations, increasing demands are placed on agricultural systems to produce greater yields through the more efficient use of natural resources. Worldwide, there are 500 million smallholder farms (<2 ha), in which 80 percent of the food that is produced is consumed within Asia and Africa (IFAD 2011). As a result, considerable research and international development resources have focused on promoting the long-term productive capacity of smallholder farming communities and improve food security. These development approaches often focus on promoting “green revolution” technologies (Fitzgerald 1986; Perkins 1997) and other approaches designed for large-scale production, including conservation agriculture, without regard for adapting these technologies to meet the needs of rural farming communities. Conservation agriculture includes the practices of minimum tillage, improved crop varieties, intercropping, and the use of cover crops that help to mitigate soil nutrient depletion, land degradation, and increase yields (Hobbs et al. 2008). Extensive global promotion of these practices has resulted in 72 million hectares of conservation agriculture systems worldwide with an estimated average growth rate of and additional 7 million ha per year (Freidrich et al. 2012). Moreover, 105 million hectares of no-till agricultural land were recorded in 2008, though this has been primarily on large-scale farms (Derpsh & Friedrich). Conservation agriculture has been promoted because it requires simple changes in farming techniques, which can be a more economically viable approach for rural farms as compared with other soil and water conservation technologies. In the United States alone, it is estimated that the decreased erosion that has resulted from conservation tillage practices resulted in a savings between 90.3 and 288.8 million USD (FAO).

This top-down approach of “modern” agricultural technologies for the global South, however, has recently been called into question and there is a lack of evidence to support long-term agricultural and environmental improvement (Giller et al. 2009). In fact, recent studies have indicated that conservation agriculture may not be the most appropriate way to increase farming capacity at the local and community scales due to problems associated with competing uses for crop residues, increased labor demand for weeding, and lack of access to, and use of external inputs (Giller et al. 2009).

In addition to issues associated with the hidden costs of conservation agriculture, many agricultural development programs make global recommendations with little regard for farmers’ existing beliefs, or so called “mental models”, of existing or new farming practices/technologies and their perceived impacts on productivity. Perhaps because of this disconnect between the way in which researcher and rural farming communities conceptualize new technologies and integrate them into existing decision-making processes, new practices introduced by government extension, Non-Governmental Organizations, or other research institutions are often abandoned for traditional practices after development projects have been completed (Bunch 1999, Cochran 2003, Yadav 1987). More recently, a review of conservation agriculture studies revealed that there are few, if any, universal factors that determine the adoption of new technologies and the factors that influence local adoption are highly contextual and tend to vary due to differing local and ecological conditions (Knowler & Bradshaw 2007). Thus, it is crucial to consider the bottom-up perspective when approaching the introduction of agricultural development programs, encouraging a community and stakeholder participatory approach in order to design project goals and objectives that serve the interests of multiple farm stakeholder groups (Chambers 1994;

Pretty 1995). Studies have found that conservation approaches promoted in developing countries as universally applicable scientific methods may actually reflect the particular social and historical contexts of their genealogy, for instance, in the case of biodiversity protection (Goldman 2011) and soil erosion prevention (Forsyth 2011). Therefore, when promoting conservation agriculture in international development, it is necessary to critically scrutinize its assumptions and to ask whether the promotion of new technologies, including conservation agriculture practices, are locally appropriate and how different perspectives about agricultural beliefs and expected outcomes can be aligned to increase the success of international conservation development.

This research adopts an interdisciplinary and empirical approach to understand the relationship between trends in expert and rural farmer reasoning and predictions regarding the outcomes associated with development technology based on these beliefs. Further, we seek to compare these differences in understanding with local environmental conditions and measured development outcomes in terms of farm production (i.e. yield). At the center of our study is an interest in comparing differences between expert and locally-based environmental knowledge regarding the dynamics of farming systems. These two knowledge systems increasingly interact in the agricultural development sector, including conservation agriculture projects, across the globe. Knowledge systems are typically categorized based on local knowledge (e.g. lay or traditional) or scientific knowledge. Local knowledge is typically drawn systematically from personal experiences or generational knowledge, while scientific knowledge is gained from structured ways of knowing, based on principles that place high importance on reliability, validity, and repeatability of knowledge claims and generalizable implications (Gray et al. 2012). The literature shows that local ecological knowledge is expected to vary given changes in local, social, and environmental conditions (Berkes et al. 2000; Folke et al. 2005). Furthermore, knowledge of ecosystem dynamics gained from historical experience become culturally embedded and are an important part of developing adaptive management strategies (Berkes et al. 2000). The identification of the environmental and/or social and cultural conditions that act as pre-cursors to affect farmer decision-making will be invaluable in developing a greater understanding of the mechanisms in how rural farmers understand various agricultural practices and their views of introduced practices that are promoted by researchers and extension personnel. Recognizing these key factors will also expose hidden assumptions and blind spots in “scientific” approaches that may be overlooked with the conventional top-down development approach. The specific objectives of this research are: (i) to understand how environmental conditions and social contexts may influence agricultural beliefs or perceptions, (ii) to estimate how these different beliefs may influence the predicted outcomes of introduced conservation agriculture practices, (iii) to assess the accuracy of the predicted outcomes of conservation agriculture practices via empirical farm-based measurements.

Although criticisms of top-down approaches and over-reliance on expert knowledge have been around for some time (Arnstien 1969), methods that measure the differences between local and scientific knowledge remain under-developed. Further, many models suggest that the promotion of social-learning between development personnel and local communities are qualitative and explain only the general processes that should occur with less attention paid to generating empirical data to validate or reject these suggested models. However, by specifically identifying the differences in perception resulting from local ecological knowledge as compared with scientific knowledge, we can better understand where these differences originate and develop improved methods for creating shared knowledge and improved collaboration. In this study, we seek to understand the differences in perception of the agricultural system by combining aspects of 'mental modeling' (Gray et al. 2014). As a case study, we will use farmers and scientists engaged in an agriculture development project and utilize soil and crop science to better understand how knowledge of agricultural dynamics are initially developed, how these beliefs may influence expected outcomes of introduced technologies, and how these expectations compare to measured agricultural outcomes.

2.1.1 Mental Models

First introduced by Craik (1943), today the notion of mental models and their use for understanding individual and group decision-making is a widely accepted construct in the social science literature (Jones et al. 2011; Gray et al. 2014). Mental models are the internal constructs that provide interpretation and structure of an external environment and are therefore an important component of how individuals make decisions. These internal representations are often constructed as individuals navigate time and space, modifying their understanding of the world around them, filtered by culture and influenced by environmental conditions and new experiences. The ways in which different representations of the world are organized, socially influenced, and made useful for understanding the management of natural resources has seen increasing attention in recent years (Kellert et al. 2000, Gadgil et al. 2000, Armitage 2003, Brown 2003, Davis & Wagner 2003). Shared mental models within communities are essential to the way societies structure their environments and build expectations and are therefore an important part of an organized society, including the establishment of norms and laws which influence decisions.

Individuals and societies with different cultural and environmentally mediated learning experiences may have different theories to interpret the world around them. Agricultural decision-making processes are complex, and it has been suggested that these decisions cannot be unilaterally explained solely from a scientific perspective (Soleri et al. 2000). Approaches that allow for active participation of the target community have been shown to result in cultivation practices that are better suited to the local environment and that empower the community (Ceccarelli & Grando 2006). In working at the community level, Denzau and North (1994) state that, "Individuals with common cultural backgrounds and experiences will share reasonably convergent mental models, ideologies and institutions and individuals with different learning experiences (both cultural and environmental) will have different theories (models, ideologies) to interpret that environment". Our study's framework is adopted as a means through which to understand the interaction between technological and ecological dynamics by examining how factors and their perceptions, collected from community farmers and university researchers, may influence subjective knowledge about the natural environment and how this influences production and management decision-making in the context of rural agricultural development. In this research, we suggest a conceptual framework demonstrating how knowledge is constructed, as well as how predicted outcomes, or beliefs, impact decision-making processes and subsequent actions. As indicated in Figure 2.1, we suggest that both environmental and socio-cultural factors contribute to developing beliefs about the dynamics of agricultural systems, leading to distinct differences in the mental models of individuals engaged in agricultural development. Exposure to local environmental conditions can influence an individuals' understanding of the functioning and interrelationship between factors such as weather, soil, and crop production as individuals collect and encode this information in their minds over time. Additionally, these real world experiences are mediated by socio-cultural factors, such as community norms and expectations, which, in part, influence what information is relevant and the behaviors that lead an individual's collection and encoding of the environment over time. These agricultural beliefs are then used by individuals as a foundation for predicting the outcomes of cultivation practices (in terms of factors such as yield, soil condition, food security, and income) and thus influence decision-making regarding the appropriate actions and behaviors adopted. In turn, the agricultural outcomes, which may or may not coincide with the predicted outcomes, may create positive or negative feedback, which would either support the adoption of successful practices or create changes in understanding through learning to adapt beliefs, predicted outcomes and future actions/behavior, respectively. It is proposed that this feedback would ultimately alter the environmental and socio-cultural conditions.

To validate our proposed model in the context of an agricultural development project, this research focuses on modeling the agricultural belief systems of agricultural development experts and communities practicing subsistence agriculture in the mid-hills of central Nepal. Specifically, we focus on measuring the difference in understanding with particular focus on two conservation agriculture practices: (1) minimum tillage and (2) continuous year-round cover cropping. By measuring the difference in these beliefs, we intend to demonstrate how different understanding of the dynamics of agricultural systems found between communities can shape decision-making regarding cultivation methods, crop selection, and management practices. A comparison of mental models from different stakeholder groups can explicitly identify knowledge gaps and incongruent beliefs. Identifying these gaps will facilitate and improve the sharing of information, contribute to clearer communication, and ultimately help to develop shared ownership of conservation plans (Biggs et al. 2011). With this information, researchers and extension personnel can develop adoption strategies or extension materials in conjunction with the farm community.

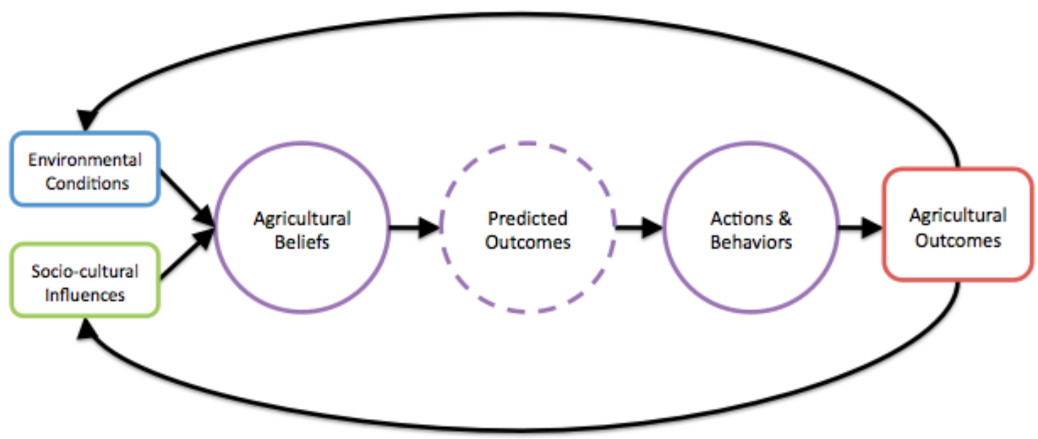


Figure 2.1. Conceptual framework for understanding the factors that influence knowledge construction, predicted outcomes based on shared knowledge, appropriate actions and behaviors based on this knowledge, and agricultural outcomes.

While this approach is highly localized, requiring research tools that can be modified and analyzed at the community-level, this assessment will garner the type of locally specific information that has been lacking with traditional approaches to community development. Both Giller et al. (2009) and Knowler & Bradshaw (2007) have recognized the need for local adaptations of conservation approaches due to varying environmental conditions and cultural contexts. Moreover, development agencies have supported this approach through the development of programs such as the United States Agency for International Development's Feed the Future Innovation Lab for Collaborative Research on Sustainable Agriculture and Natural Resource Management, which has created a global effort to identify key issues in conservation agriculture implementation by studying communities at the local scale. Such large-scale operations can be used to identify common challenges, allowing for the scaling up and application of the research findings in similar geographical and/or cultural situations.

2.1.2 Study Area

This study takes place in three rural communities in the central mid-hill region of Nepal engaged in a conservation agriculture-based development project. The study communities were selected to take part in the study in consultation with a local Non-Governmental Organization and were indicated as highly impoverished and at great risk of food insecurity due to their marginal agricultural lands, small landholdings, and potential for malnutrition. The communities studied in this survey are characterized by smallholder subsistence farming households, with typically less than 2 ha of arable land, and limited opportunities available for income generation.

The central mid-hill region comprises 42% of the total territory of Nepal. More than one third of the country's total agricultural land is located in this region, feeding 44% of the country's population of 29.8 million (Thapa & Paudel 2002). For these reasons, it has become a major area of focus for reducing food security vulnerabilities and implementing agricultural adaptations for climate change. Much of the region's agricultural production is from smallholder subsistence farmers using traditional continuous cultivation methods of terracing, plowing with draft power, and sole cropping in a rice and maize-based agricultural system. In recent years, however, growing populations and deteriorating agricultural land has led to an increased need for improved agricultural technologies to increase soil and water conservation as well as crop yields. Local Non-Governmental Organizations and university researchers have been working in these communities to introduce improved cultivation methods, however, there exists a gap in the agricultural specialists' understanding of the farmer's motivation and willingness to adopt new practices (Kerkhoff & Sharma 2006, Khadka 2010). It is particularly important to consider the differences in perspective of agricultural professionals, whom are often responsible for designing and introducing agriculture development projects, as compared with rural subsistence farmers, whom are expected to adapt their traditional agricultural practices, practices upon which their livelihood rests.

Three villages in the central mid-hill region of Nepal (Figure 2.2) were studied, and represent communities highly reliant on agriculture production with limited resources for income generation available. The members of the villages are predominantly from the Chepang tribal group. The selected villages were *Thumka*, in Gorkha District, *Hyakrang*, in Dhading District, and *Khola Gaun*, in Tanahun District. Village sizes included 16 households in Khola Gaun, 25 households in Hyakrang, and 36 households in Thumka. Available demographic data for the villages are shown in Table 2.1. In these areas, farming systems are maize and rice based, using predominantly local crop varieties. Additionally, farmers can no longer use shifting cultivation due to scarcity of land and they currently follow conventional tillage practices (full plowing twice before sowing), use relatively low inputs of fertilizer, and leave land fallow and exposed in the winter season. Such practices tend to degrade land quality and result in decreasing crop yields over time.

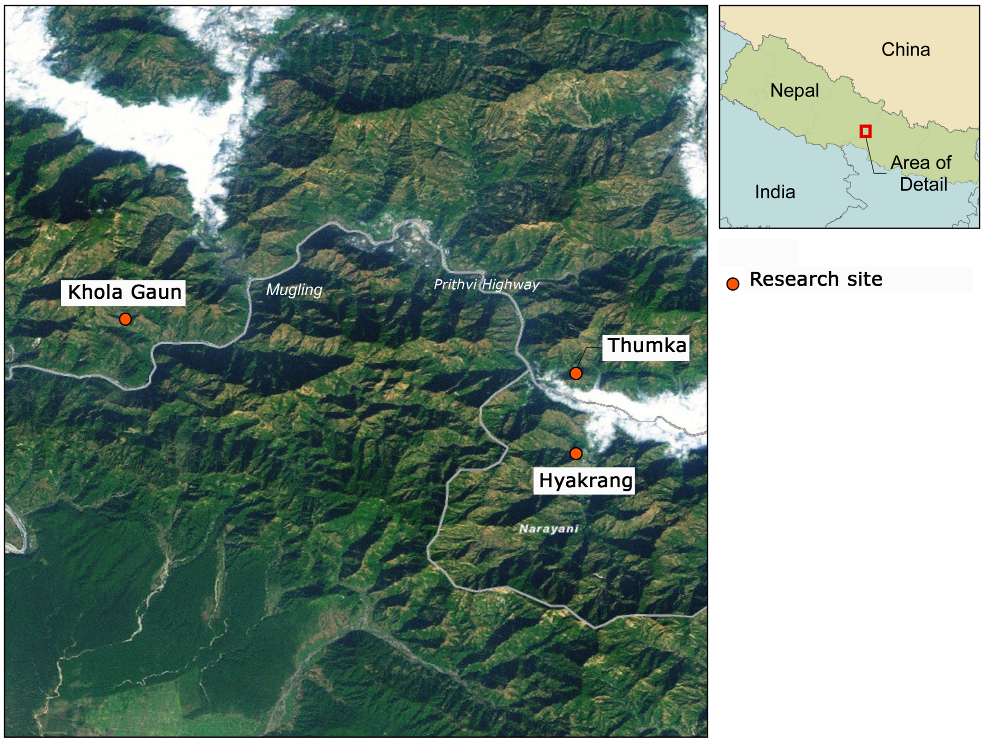


Figure 2.2. Map of Study Area, Central mid-hills, Nepal.

The characteristics of the villages in our study site, as rural farmers engaged in farming on marginalized land, typify many areas commonly subjected to international agriculture and conservation development. Recent studies have shown that conservation agriculture practices have been successful in sustaining productivity in lesser-developed countries traditionally using “slash and burn” techniques. Due to population pressures, the abundance of land required to implement slash and burn, which requires shifting agricultural land to fallow plots every year to maintain productivity, is has been steadily declining and the practice is now seldom used in the study area. The conservation agriculture practices of minimum tillage and the use of cover crops are an alternative that may help to mitigate soil nutrient depletion, land degradation, and increase yields (Hobbs et al. 2008). These practices have been successfully adopted in many developing countries with similar terrain and social and cultural backgrounds such as the focal area of this study. Despite such demonstrated approaches to improving agricultural productivity and maintaining the richness of the soil environment, the successful introduction and later adoption of these conservation practices depends on appropriateness of the practices for the local environment, the way in which such practices are introduced, as well as their alignment with the community’s existing belief systems regarding the agricultural practices (Isaac et al. 2009).

Research agencies such as local Non-Governmental Organizations and agricultural universities are beginning to work with subsistence farmers in Nepal to introduce conservation agriculture practices.

Table 2.1. Village Demographics

Village	No. Households	Average Annual Income (USD)	Average Family Size	Education Level	Average Farm Size (ha)
Thumka	25	554.12	10	Primary	0.62
Hyakrang	36	622.31	7	Primary	0.63
Khola Gaun	16	626.95	6	Primary	0.58

All data shown represent the average per village. (Reed et al. 2012).

2.2 Methods

2.2.1 Measuring Agricultural Beliefs

As a way to measure the differences in mental models between stakeholders engaged in a conservation agriculture development project, we used a parameterized and semi-quantitative concept mapping technique called Fuzzy-logic Cognitive Mapping. Originally developed by Kokso (1986), Fuzzy-logic Cognitive Mapping was originally developed as a way to structure expert knowledge under conditions of uncertainty. Due to its flexibility to model any domain, this has been applied in several disciplines from psychology to politics in order to model belief systems of individuals as well as those of communities. This study uses Fuzzy-logic Cognitive Mapping to identify mental model representations of factors and the relationships between environmental conditions (e.g. soil moisture and soil nutrients), farm-based dynamics (crop yield, crop sales, crop selection) and introduced technologies (e.g. conservation agriculture practices). This method was selected to quantify differences in group beliefs since it serves as a tangible method to represent similarities and differences between the understandings of the various stakeholder groups through explicit knowledge representation from individuals that can be aggregated to understand trends in community beliefs (Gray et al. 2014).

Due to the literacy constraints of the farm respondents, we used an adapted application of Fuzzy-logic Cognitive Mapping to develop mental model representations in two steps. First, we conducted initial interviews with rural farmers in all three villages to gain an understanding of their beliefs about which variables and their relationships are important to understanding farm dynamics. Second, based on these interviews, we developed a quantitative survey to construct a cognitive map for individuals within villages and for experts that could then be aggregated by group to understand trends in beliefs in each of the groups in the study.

2.2.1.1 Initial Interviews

In 2012, face-to-face interviews were conducted with farmers from the three Chepang villages to gather a broad understanding of the variables involved in the village farming system. To develop a general mental model of the three Chepang communities' view of their agricultural system and farming practices, first the farmers were asked to name the important factors of the farming system and to describe their understanding of farm dynamics. Survey enumerators were instructed not to prompt respondents to ensure that the mental model variables were not influenced by external expectations and perceptions. The most common responses from the initial survey were used to understand the variables and the causal relationships between variables to create a general concept map (Figure 2.3) intended to represent the typical understanding of farmer's perceptions of the agricultural system. This concept map was then used to develop a more in-depth survey to be administered to individual farmers and researchers to measure the strength of the relationships between the relevant factors of the agricultural system collected from the initial interviews.

The Fuzzy-logic Cognitive Mapping-based survey developed from initial interviews was administered to farmers from the three villages of Thumka, Hyakrang, and Khola Gaun, as well as with agronomy researchers from Tribhuvan University's Institute of Agriculture and Animal Sciences (IAAS). Using a series of individual questions, this survey asked farmers to validate and define relationships between variables mentioned during the initial interviews and define the relationship between variables using a Likert scale. For example, soil quality and crop yield were two variables identified in the initial interviews. Participants were asked if soil quality influenced crop yield. If participants indicated there was a relationship, follow-up items asked them to define the relationship as positive or negative and the degree of influence of that relationship using scale from strong negative (-1) to strong positive (+1). Each variable was defined to avoid the risk of misinterpretation or varying understandings of the variables. Individual survey responses were then translated into an adjacency matrix to determine the level of influence of one factor on another for Fuzzy-logic Cognitive Mapping-based scenario analyses following methods described by Ozesmi and Ozesmi (2004). To develop trends in community beliefs, community models were developed by taking the arithmetic mean of individual survey results, representing each of the three villages and the researcher group perspectives of the existing agricultural production system. Specific questions related to conservation agriculture technologies, not included in the initial interviews, were also included in survey to link the conservation agriculture practices of tillage and soil cover to perceived dynamics of the agricultural system. As the farmers were unfamiliar with the specific conservation agriculture practices of minimum tillage and cover cropping, basic descriptions of these cultivation methods were provided without detailing their expected attributes so as not to influence the responses.

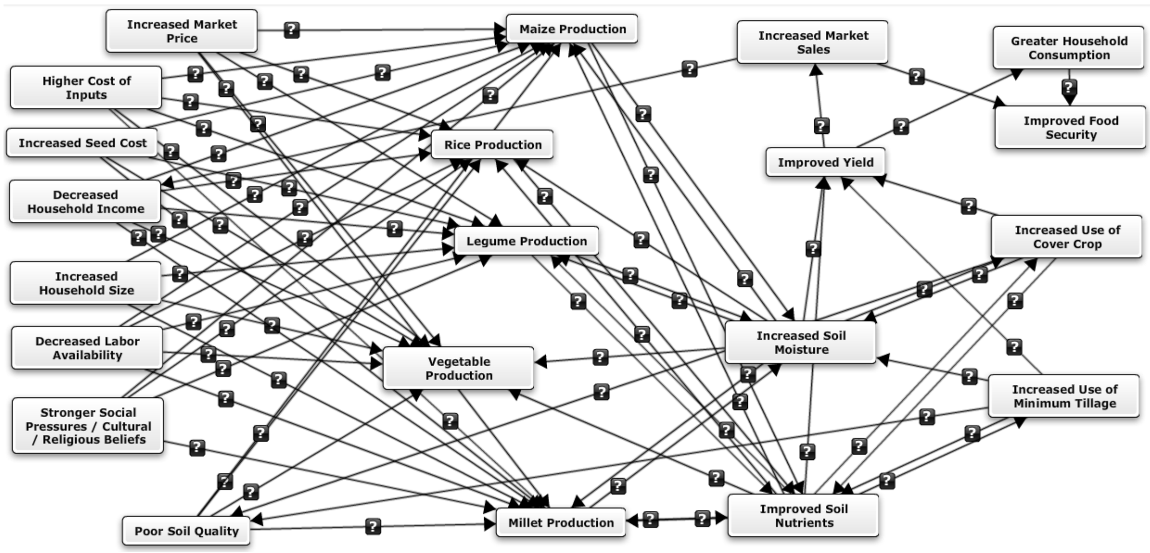


Figure 2.3. General concept map of factors in the agricultural system.
Constructed using fuzzy-logic cognitive mapping software *Mental Modeler* (Gray et al. 2013).

2.2.1.2 Belief-based Predictions of Conservation Agriculture

After survey responses were aggregated into four community models (one for each village and one for experts) by combining the individual adjacency matrices, two scenarios were run to assess the predicted changes to agricultural systems. These represented the introduction of two conservation practices: (1) minimum tillage and (2) year-round cover crop. These scenarios were used to predict the perceived changes to the agricultural system based on the strength of the relationships between factors, determined using the averaged models of each village and the experts. For the scenarios, matrix calculation was used to determine possible changes to the model under specified conditions by subtracting a scenario condition from the steady state conditions following methods described by Kosko (1986) and elaborated by others (Ozesmi & Ozesmi 2004; Gray et al. 2012). The identified conservation agriculture variable/s in the community models were then subjected to Kosko’s “clamping” method to introduce an increase in select variables to understand changes in the agricultural systems when variables were artificially increased or decreased. For example, in the first scenario, minimum tillage was artificially increased to a value of 1 in the matrix calculation for each community model to show the predicted impacts of the practice on the other model components. Based on the strength and direction of the relationships expressed in Figure 2.3, the results from the scenario analysis show the response in terms of estimated relative change in each variable included in the community models. Similarly, the second scenario involved artificially increasing the value of the cover crop variable to 1. Scenario outputs for the two conservation practices were compared by variable for each group. Comparisons of the two conservation scenarios indicated how villages and experts anticipate the impact of introduction and/or implementation of (1) minimum tillage and (2) year-round cover cropping, based on differences in their beliefs about agricultural dynamics.

2.2.2 Conservation Agriculture Outcomes

To compare the mental model-based predictions of conservation agriculture practices to measured agricultural impact, we also evaluated crop yield in conservation agriculture experimental plots in each of the three villages. On farm experimental plots were established on 8 representative farms in each of the three villages during the cropping season of 2012. Treatments for comparison included (1) a simulated farmer practice of fully plowed maize (March-July), followed by a relay planting of millet (July-September) intercropped with cowpea, and concurrently (2) strip tillage with maize, followed by a relay planting of millet intercropped with cowpea. An analysis of variance was used to determine significant differences of crop yield under minimum tillage as compared with the farmer's practice of conventional full tillage.

2.2.3 Environmental Conditions

In addition to understanding the relationship between mental model predicted impacts of conservation agriculture compared to measured outcomes, we also wanted to evaluate differences in how environmental conditions may impact beliefs. To accomplish this, multiple soil physical and chemical analyses were conducted in the villages to determine pre-existing agricultural conditions and identify localized differences in soil conditions. Further, these measurements were compared to community models of soil characteristics (soil moisture and soil nutrients) to understand if variation in soil contributed to the agricultural beliefs of farmers. Baseline soil samples (0-5 cm and 5-10 cm depths following plowing) were collected in March 2011 from each farmer plot in each village. Bulk density, percent organic matter (Walkley-Black method), percent nitrogen (Kjeldahl titration method, Bremner 1960), available K and P (ammonium acetate extraction), pH (in water), and texture (hydrometer method), and coarse materials (non-organic, > 2mm) were determined in the LI-BIRD Plant and Soil Nutrient Laboratory, Pokhara, Nepal. A subsample of soil was transported to the Virginia Tech Soil Testing Lab, Virginia Technological University, Blacksburg, VA. There, an inductively coupled plasma analysis was used to determine P, K, Ca, Zn, Fe, Cu, and B concentrations (mg kg^{-1}) on Mehlich-I extractant (Mehlich 1967). Base saturation, effective cation exchange capacity and

Ca, K, P saturation were calculated using the inductively coupled plasma results. A principle components analysis was conducted using PC-ORD (software version) to assess and characterize the chemical and physical properties of on-farm soils at the 0-5 and 5-10 cm depths from each of the villages. Linear comparisons among village means were conducting using PROC MIXED in SAS (v. 9.x.x) to identify statistical difference for selected variables.

2.3 Results

There were a total of 103 survey respondents representing members of university/researcher (N=25) and the villages of Thumka (N=31), Hyakrang (N=25), and Khola Gaun (N=22). The demographics of the survey respondents are listed below in Table 2. With the village sizes ranging from 16-36 households, over 50% of households in each village participated in this study. The gender distribution for the researcher/university respondents was 48% female and 52% male, while in the villages the average female to male respondent ratio was distributed at 53:47 percent. The majority of respondents were the male or female heads of household or the key decision-makers for agricultural activities. All research/university respondents had a minimum of a secondary school education, with the average education being at the Master's level. Village farmers had an average education at the primary school level. Of the village respondents, average ages ranged between 33 and 40 years with researcher/university respondents' average age of 27.

2.3.1 Differences in Agricultural Beliefs

The community cognitive maps generated for each group indicated differences in the dynamic relationships and relative influence between factors for the four groups (Table 2.2). The differences between community-level models were identified by assessing the overall structure of the models for the relationships between variables including whether they were positive, negative and the strength of the relation. Each of the models varied somewhat with the complexity of the researcher model higher than those of the villages. The researchers had an average of 60 (St. Dev.=9) perceived connections between factors, while the villages of Thumka, Hyakrang, and Khola Gaun had 46, 46, and 50 connections, respectively (St. Dev.=12, 12, 13). While the village models had less connections overall, the number of connections between factors varied by village as compared to the researcher's averaged model. Table 2.3 outlines the key differences between the groups for the relevant factors relating to crop production and soil conditions. The values show a strong negative (--), negative (-), positive (+), strong positive (++), or no perceived relationship between the factors (0). In many cases, minimum tillage was perceived as having no relationship with soil or yield; however, both Hyakrang and Khola Gaun perceived a negative relationship from minimum tillage on soil quality and yield (boxes highlighted in orange).

Table 2.2. Survey respondent demographics, listed by group.

Group	Description	Number of participants	Gender		Average Age	Typical Education
			Female	Male		
IAAS	Research / University	25	12	13	27	Master's
Thumka	Village	31	16	15	33	Primary
Hyakrang	Village	25	14	11	40	Primary
Khola Gaun	Village	22	11	11	39	Primary
TOTAL		**103**	**53**	**50**		

Figure 2.4 shows the variables and the relationships included in the initial interviews used to develop the individual mental model survey and the four group-level cognitive maps for the villages and the expert group. Positive (blue) and negative (red) perceptions are indicated for each relationship, with the thickness of the line indicating the strength of the relationship on average. The influence of any one variable on the rest of the model is determined by the strength and direction of the transmitting and receiving variables directly connected to that variable. The greater interconnectivity of the researcher community model (Figure 2.4a) indicates that this group perceives causal relationships between more variables in the system and generally views the system as more complex in terms of its network structure. The researchers are expected to derive their understanding of the agricultural system from formal and generalized knowledge, which may not always be applicable to local farming conditions. In contrast, farmers derive much of their understanding from experience and local ecological knowledge, resulting in a simplified model that may be more reflective of the local environment.

2.3.1.2 Differences in Belief-based Impacts of Conservation Agriculture

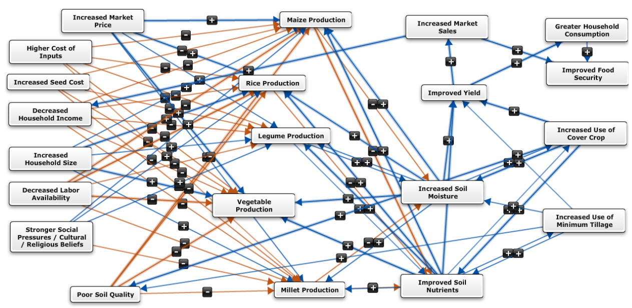
For the first conservation agriculture scenario, in which conditions of minimum tillage are introduced, the clamping method was applied to the factor “increased use of minimum tillage”. The results are represented in Figure 2.5 as the predicted changes to the model under minimum tillage and indicate how farm dynamics are expected to change under this condition. The scenario results indicate that the strongest differences between the predicted impacts with the introduction of this technology are apparent in the factors relating to soil conditions and crop yield. With respect to soil moisture and soil nutrients, all groups except Hyakrang village expected improvement from the introduction of minimum tillage. However, in terms of soil quality, the scenario analysis showed that all groups except Hyakrang and Khola Gaun villages expected an improvement to soil quality. Similarly, with regard to crop yield, Thumka village and the researcher group showed a positive change in terms of increased yield, while Hyakrang and Khola Gaun expected a decline in yield. For each of the abovementioned factors, the researcher group showed the strongest positive change in the model, as compared with the village responses.

Table 2.3. Key differences between groups in community cognitive models.

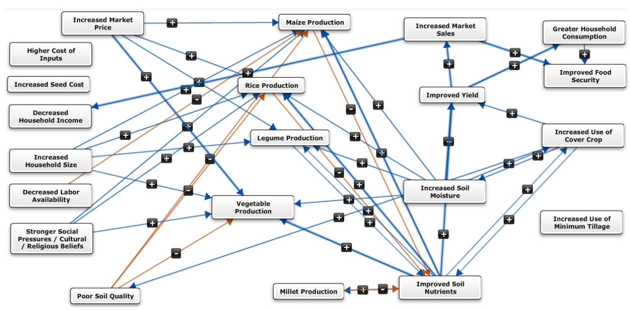
Transmitting Factor	Receiving Factor	Researchers	Thumka	Hyakrang	Khola Gaun
Soil Quality	Millet	-	0	0	-
Maize production	Soil Moisture	-	0	-	0
Maize production	Soil Nutrients	--	-	-	0
Rice production	Soil Nutrients	-	-	0	0
Legume production	Soil Moisture	+	0	0	0
Millet Production	Soil Moisture	-	0	-	0
Millet Production	Soil Nutrients	-	-	-	0
Soil Moisture	Millet Production	+	0	0	+
Minimum tillage	Soil Quality	+	0	0	-
Minimum tillage	Yield	+	0	-	-
Minimum tillage	Soil Moisture	+	0	0	0
Minimum tillage	Soil Nutrients	+	0	0	+

In the second conservation agriculture scenario, introducing cover cropping during the fallow season, the factor “increased use of cover crop” was clamped as artificially high. The results, shown in Figure 2.6, demonstrate that all study groups show similar expectations under this condition and would expect a strong positive change to soil nutrients, soil moisture, crop yield, and soil quality with the introduction of a cover crop. Again, the researcher group showed the strongest agreement in expected change as compared with the village groups. In terms of soil quality, Thumka village also showed stronger agreement regarding the positive effect of cover cropping, as compared with the other villages. These results indicate that there is homogeneity in the expected impact of increasing cover crop across all groups.

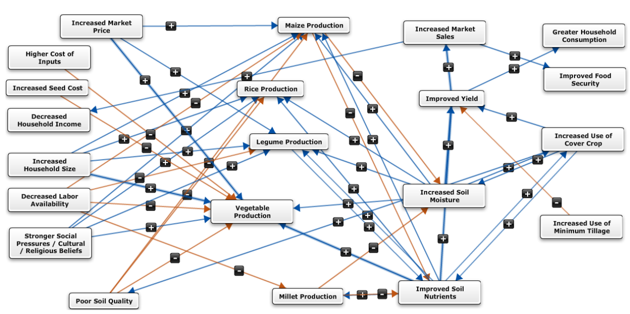
2.4a. Researcher community model



2.4b. Thumka community model



2.4c. Hyakrang community model



2.4d. Khola Gaun community model

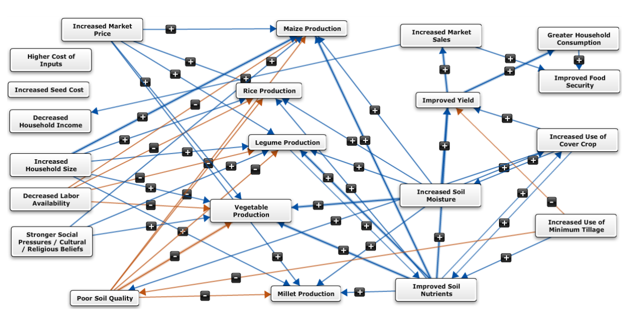


Figure 2.4a-d. Averaged community models of environmental, farm-based, and conservation agriculture dynamics for the study groups.
(a) Researcher, (b) Thumka, (c) Hyakrang, and (d) Khola Gaun. Constructed using fuzzy-logic cognitive mapping software *Mental Modeler* (Gray et al. 2013).

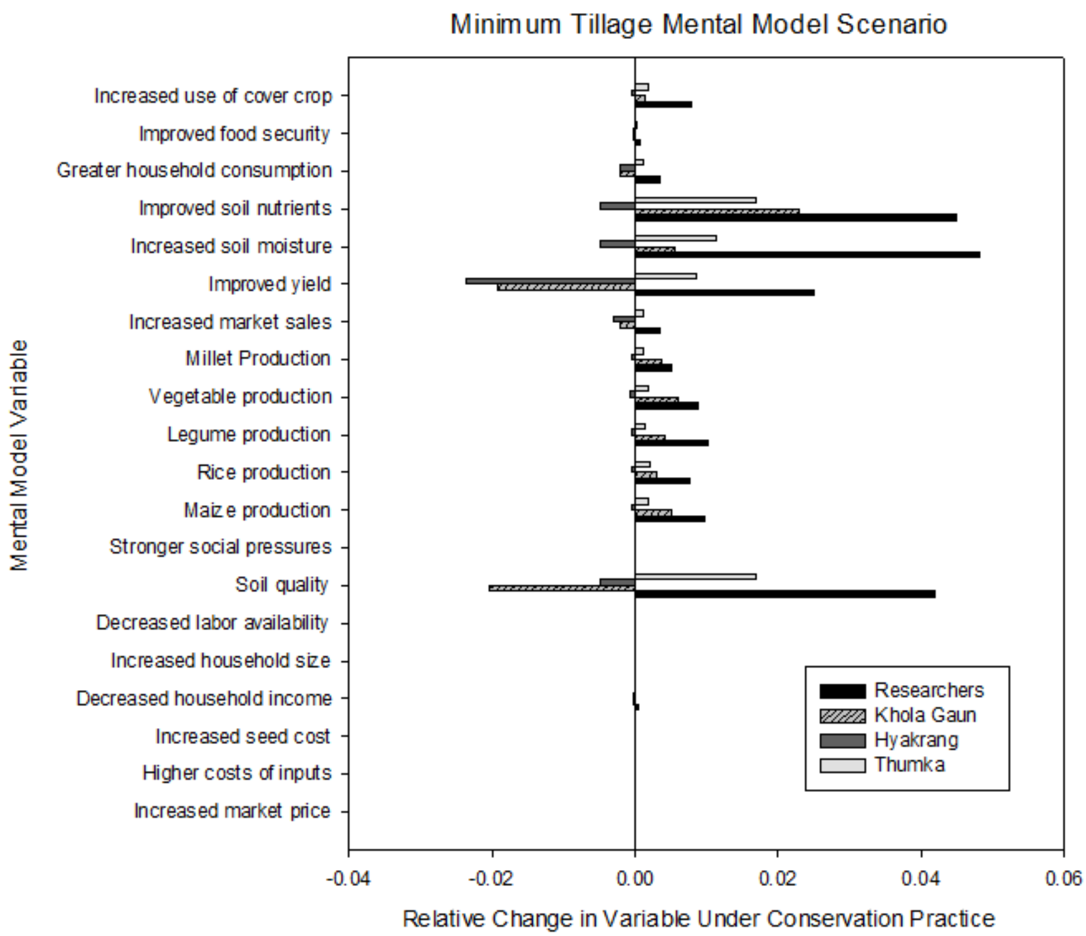


Figure 2.5. Relative strength of factors under a minimum tillage scenario. Values represent relative change from the steady state condition and are aggregated by group.
Note: This figure represents the perceived changes to factors as a result of increasing minimum tillage. Relevant results are those that compare the groups to each other for only one factor and not across factors. Higher + or – values indicate stronger agreement among the group.

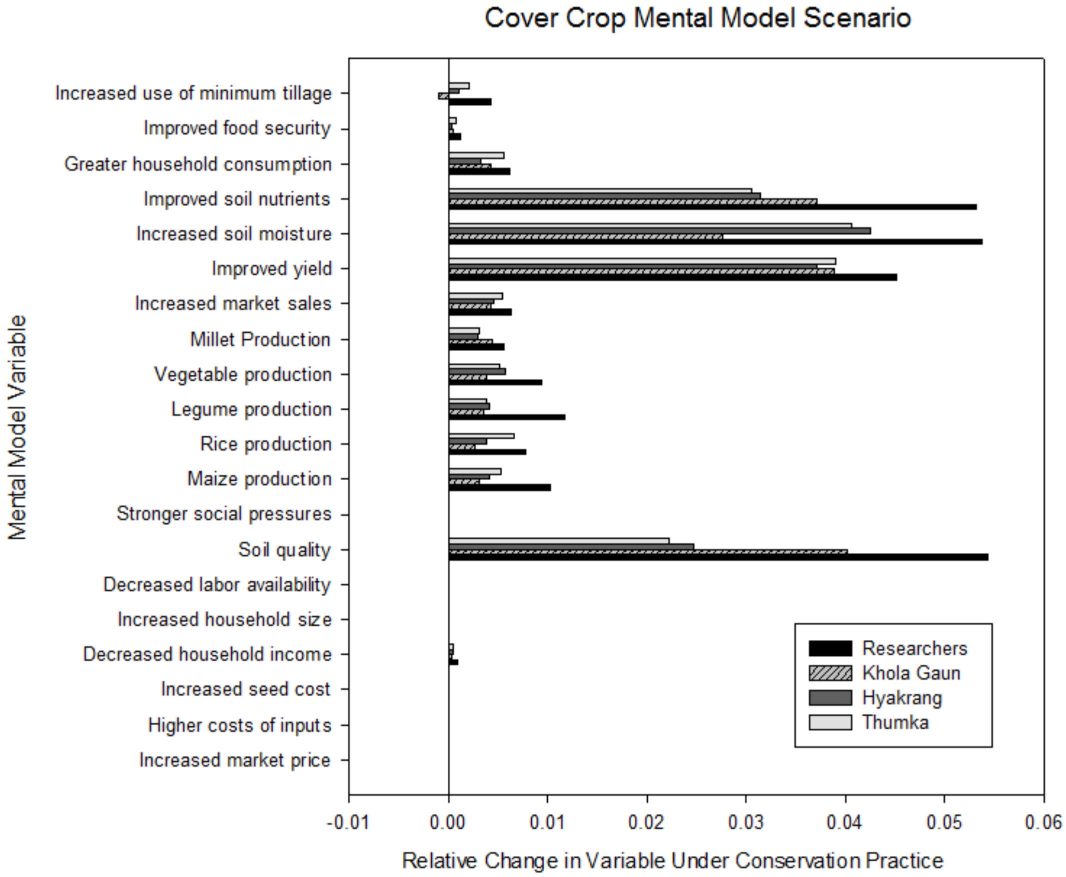


Figure 2.6. Relative strength of factors under a cover crop scenario. Values represent relative change from the steady state condition and are aggregated by group.
Note: This figure represents the perceived changes to factors as a result of increasing use of a cover crop. Relevant results are those that compare the groups to each other for only one factor and not across factors. Higher + or – values indicate stronger agreement among the group.

2.3.2 Measured Conservation Agriculture Outcomes

Average maize yield in 2012 was 1,917 kg/ha for Hyakrang, 1,554 kg/ha for Khola Guan and 1,373 for Thumka. Yields in Hyakrang were statistically higher than in the other two villages. However, there were consistent trends in experimental yields among the villages with regards to the effect of minimum tillage. Maize yield in minimum tilled plots was on average 16% lower than yield in full tillage plots. Yield reduction associated with minimum tillage was most evident in Thumka with a 26% reduction in maize (Figure 2.7).

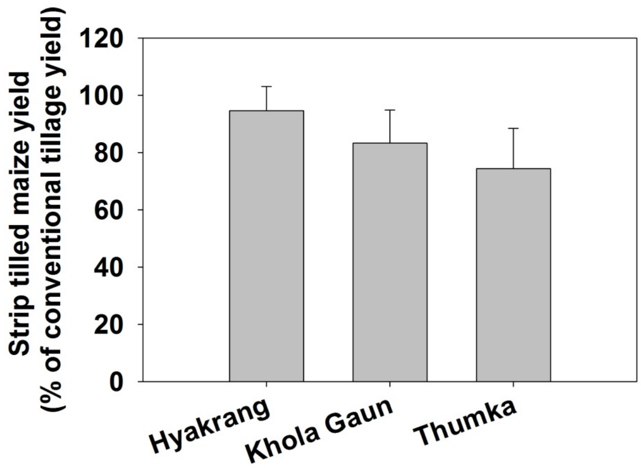


Figure 2.7. Yields from minimum (strip) tilled plots expressed as a percent of yield compared to traditional (full) tillage plots in each village.
Nepal 2012. Mean values are from 8 fields in each village. Error bars are mean standard errors.

2.3.3 Environmental Conditions

The results of the soil analysis indicate clear distinctions between soil properties across the three villages (Figure 2.8). Both Hyakrang and Khola Gaun showed a higher proportion of sand content, which is characteristic of lower water retention and relies on a higher percent organic matter for productivity. Organic matter was found to be high in Khola Gaun, where available nitrogen, phosphorus, potassium, and higher rates of ECEC were also present. Hyakrang showed lower values for percent organic matter, as well as available P and K, though Thumka was also found to be lacking in these nutrients though had high percent organic matter. When compared to the community beliefs, this is consistent with Thumka not perceiving a strong relationship of tillage with the other agricultural factors. Both Hyakrang and Khola Gaun related tillage with crop yield, which was consistent with the condition of the village soils requiring incorporation of organic matter for improved production.

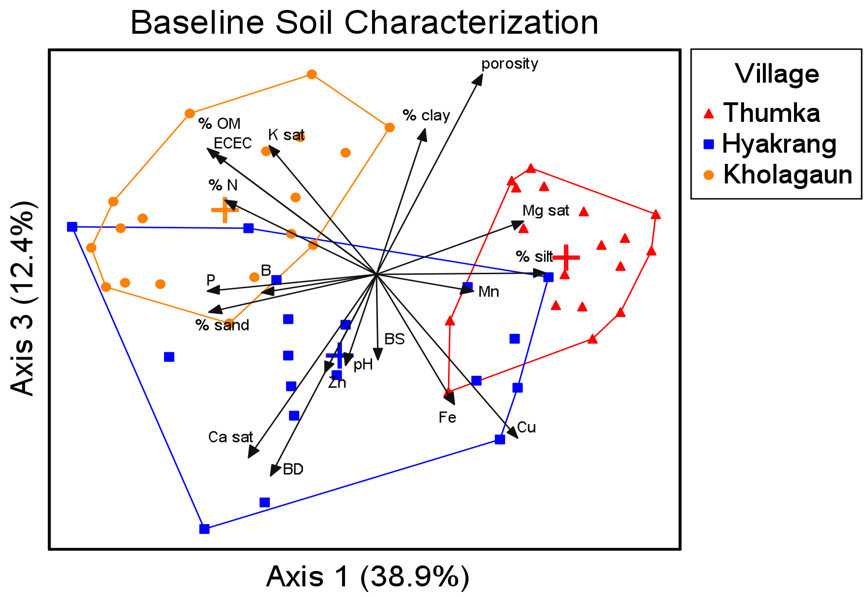


Figure 2.8. Principal components analysis of baseline chemical and physical properties of soil collected from both the 0-5 cm and 5-10 cm depths. Nepal 2011.

2.4 Discussion

Rural agricultural development is inherently complex, bringing multiple stakeholder groups from Non-Governmental Organizations, research institutions, extension, and rural communities together for the promotion of sustainable yet sufficient agricultural production. Many development projects have historically used a top-down model, applying scientifically established technologies to rural farming systems (Herdt 2012). However, technical expertise often fails to take into account the local ecological and cultural context that may conflict with project objectives. Research in the field of ethnobotany highlights the need to quantify analyses of local systems to better understand the constraints and opportunities within the geographical and cultural landscape as well as to recognize the cultural importance of the environment (Alcorn et al. 1995, Reyes-Garcia et al. 2007). Based on our results, the introduction of unfamiliar concepts and dynamics of conservation agriculture, such as minimum tillage or cover cropping can be perceived as either consistent or inconsistent with existing community beliefs. We suggest that these differences in how experts and local communities may view introduced technologies may be impacted by (1) expectations at different temporal scales, (2) variation in environmental condition, and (3) variation in social-cultural conditions and previous interactions.

2.4.1 Differences in Agricultural Beliefs and Predicted Impacts based on Differences in Temporal Scale

Measuring differences in understanding of farm dynamics, especially in areas where soil properties or other environmental conditions are distinct may result in clear differences in the anticipated impact of development technologies, however this is not always the case and appears to differ depending on the technology promoted. For example, in our study, the effectiveness of minimum tillage was viewed by two of the three villages as having potentially negative impacts on yield, while all groups anticipated positive impacts for cover cropping. Measured yield observed in minimum tillage plots supported the majority expectation among the villages that minimum tillage will reduce yield. Interestingly, the trend for reduced yields was greatest in Thumka, the village in general agreement with the researchers' prediction of positive yield effects from minimum tillage. Admittedly, benefits from minimum tillage, when realized, are generally observed over the long-term. Forsyth (2011) describes the tendency for generalized cause and effect statements, such as “tillage causes erosion” to be held as dogmatic truths regardless of context. That may explain in part the strong belief held by the researcher community of the beneficial effects of minimum tillage. This also calls into consideration the long-term versus short-term expected gains.

Subsistence farmers must inherently make decisions based on short-term prospects, as crop yields comprise their livelihood and lack of alternate income severely limits food security. Noted short-term variability, including positive, negative and neutral effects, in the field response to the introduction of conservation agriculture can reduce the overall attractiveness to farmers of adopting such practices (Giller et al. 2009). Furthermore, farmer beliefs may be based more heavily on personal experience as well as knowledge passed down from previous generations of subsistence farmers with similar short-term objectives (Thrupp 1989). In contrast, researchers may draw from multiple sources of information, generating a broader understanding of the agricultural system, including longer temporal expectations of land dynamics, and can view conservation agriculture within the subsistence farming system objectively, seeking long-term conservation impacts and without the immediate pressures of crop yield gains. Such differing perspectives in terms of timeframe may account for the basis of predicting the outcomes of introduced conservation agriculture practices; Farmers base decisions on immediate and apparent positive outcomes, while researchers maintain a broader perspective of change over time.

2.4.2 Differences in Beliefs and Predicted Impacts based on Environmental Conditions

Our results indicate that there are critical differences between the villages in terms of existing soil conditions that may lead to differing locally-based perceptions of introduced conservation agricultural practices, their impact on soil moisture and nutrients, and the subsequent effect on crop yields. The soil analysis showed that each of the villages had distinct soil qualities, which would call for different optimal cultivation practices for sustained crop yields.

For the two conservation agriculture scenarios, minimum tillage and cover cropping, the differences in perceptions between the groups were primarily observed with minimum tillage. Overall, there was agreement among the groups in the perception of the effects of cover cropping. Namely, expected improvements to soil quality and crop yield. However, there was more agreement among the researcher group, as compared with the villages, that this would occur. The minimum tillage scenario showed a mixed response in perceived effect to the farm system. Both Hyakrang and Khola Gaun perceived minimum tillage as having a negative impact on yield and soil quality, with Hyakrang also predicting a decline in soil nutrients and moisture.

In Khola Gaun, the rocky condition of the soil would result in numerous challenges for cultivation, including low nutrient retention capacity, limited water storage, poor soil aggregation, and risk of erosion (FAO 2014, Hall 2014). This indicates that successful cultivation would be heavily reliant on incorporation of organic materials into the soil through tillage to improve soil fertility and structure (FAO 2014). This would promote nutrient availability in the soil and thus be a critical cultivation practice. Hyakrang soils showed much variation in soil properties, and may indicate a similar reliance on tillage. Such observations also support the farmers' need for short-term benefits from introduced practices. While soil organic matter and the need for incorporation of organic matter into the soil is reduced over time with conservation agriculture (Giller et al. 2009), practices such as minimum tillage do not address the short- and medium-term needs of farmers for sufficient soil nutrients.

Additionally, such varying local ecological conditions lend themselves to different adaptive management strategies, which over time develop into locally specific beliefs regarding the agricultural system (Berkes & Folke 2002). In the case of soil conditions, the villages have developed management strategies (such as incorporation of organic matter) that have been proven successful in the past. Several researchers have identified the value of indigenous knowledge and suggested that such knowledge be incorporated into participatory approaches for resource management (Sillitoe & Marzano 2009, Berkes et al. 2000). These types of methods, which allow different knowledge systems to be compared, are generally lacking (Gray et al, 2012). Additionally, explicitly comparing differences in mental model representations using methods similar to what is demonstrated in this study may support more collaborative decision-making and develop understanding that reduces institutional barriers (Roling & Jiggins 1998).

2.4.3 Differences in Beliefs and Predicted Impacts based on Socio-cultural Conditions

Lastly, our results indicate that one of the villages showed community beliefs more consistent with the researchers as compared to the other villages. The close proximity of Thumka to the highway, accessibility to the market, and a greater degree of intervention by Non-Governmental Organizations, as compared with the other villages, may partly explain the similarity between Thumka and researcher communities' expectations regarding the impact of minimum tillage. Namely, increased levels of contact with agricultural Non-Governmental Organizations, may build farmers' trust in the agencies' capacity to introduce beneficial practices over both the long- and short-terms. This is reiterated by previous studies that have shown a positive correlation between institutional support and access to information with greater adoption of introduced practices (Bohlen et al., Kebede et al. 1990, Daberkow & McBride 1998, Knowler & Bradshaw 2007).

Nevertheless, power relations between development experts and local communities in the global South may make it difficult for farmers to question the developmentalist ideas introduced by government or Non-Governmental Organizations (Mitchell 2002). To address this disconnect, it has been suggested that, social learning should occur among the different stakeholders engaged in development projects as a way to promote conditions of collaborative co-management where all parties acknowledge the value of the other's expertise (Schusler et al. 2003). Through developing a greater understanding of a community's ideas, projects can be designed to ameliorate the pressing needs of the community while promoting improved agricultural technologies; however, this requires an understanding of the temporal, spatial, and social variability of the community perceptions regarding the agricultural system (Agrawal 1995), as well as the ecological attributes and limitations of the local environment. It is also crucial that development practitioners be reflexive about the situatedness (c.f. Haraway 1989) of approaches, concepts, and knowledge used in international development.

2.5 Conclusions

There are a number of factors that add to the perception and fundamental agricultural knowledge of rural subsistence farmers, as well as of researchers. This study first determined the factors important to farmers based on their perceptions and current farming practices, particularly in regards to conservation agriculture practices, such as tillage, and coupled this data with measured environmental variables and agricultural outcomes to compare among them. From the identified set of factors and their relationships to the agricultural farming system, the study further determined that different villages and groups (farm communities compared with researchers/extension personnel) weighed these relationships differently due to experience, knowledge and the social, cultural, and ecological conditions of the groups and/or villages.

In terms of the relationship of soil conditions and conservation practices, such as minimum tillage, with yield and adoption, there are significant differences among the study groups. Researchers perceived a stronger positive relationship between soil conditions and conservation practices, which are consistent with scientific research for the long-term benefits of conservation agriculture. There are also differences among the villages in their perception of the relationship between tillage and soil moisture as well as between soil nutrients and yield. This has been linked to different ecological conditions, such as soil, as well as the farmers' inherent need to focus on the short-term benefits of cultivation practices. The implications of such varying perceptions means that extension personnel seeking to promote conservation agriculture practices in villages with differing ecological constraints may require alternate intervention strategies to address the immediate concerns of subsistence farmers while keeping future goals of conservation in mind. This includes fostering increased mutual understanding of agricultural beliefs, both from a farmer-to-researcher perspective and vice versa. Communities with fertile soils and a weak perceived relationship between soil fertility and conservation agriculture practices may be reluctant to adopt soil conservation methods despite evidence that such practices are generally beneficial to adopt. In contrast, communities with soil deficiencies and a stronger perception of the linkage between soil fertility and conservation agriculture practices may more readily adopt introduced soil conservation technologies. Researcher interactions with farmers should consider such local ecological variation and take in to account farmer's local ecological knowledge, as well as their agricultural priorities and concerns.

Developing knowledge of village perceptions with regards to the need for conservation practices to enrich the soil and increase yields can aid researchers and extension practitioners in devising optimal agricultural intervention strategies to meet the needs of communities and conservation objectives. Agricultural experience, local soil conditions, and traditional or learned knowledge all contribute to the decision-making process of whether to adopt new agricultural practices over the long-term. Planning for agriculture development projects must therefore consider the local context and perception from both the farmer and researcher/development agency perspectives to develop trust, mutual understanding, and improve the project design for the benefit of multistakeholder groups. Additionally, plans should incorporate short-term successes to meet farmers' immediate needs while contributing to long-term ecological sustainability. This research has demonstrated two important needs for practitioners and policymakers. First, the success of adoption of any introduced agricultural practice requires knowledge of the agricultural belief systems of farmers and other stakeholder groups, such as researchers and extension personnel, such that gaps in perceptions of the agricultural system are recognized and incorporated into the development of implementation strategies. Second, it is crucial that agriculture development agencies utilize interdisciplinary teams or involve interdisciplinary extension personnel to develop a complete understanding of the agronomic, ecological, and social context of a community-based project. As shown by this study, simply understanding how rural farmers think and approach agricultural decision-making does not create solutions. It is through the supplemental discovery of the ecological and social basis driving these perceptions that a more complete picture of community needs and perceptions is developed and sustained productivity can be better promoted.

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Chapter 3. Implications of Conservation Agriculture for Men's and Women's Workloads among Marginalized Farmers in the Central Mid-Hills of Nepal

3.1 Abstract

Measures of gender-based labor distribution can contribute to understanding the feasibility of agricultural development in mountainous subsistence farming communities. Conservation agriculture (CA) can provide sustained crop yield and improved soil and water conservation in mountain areas prone to degradation where few inputs are available. This study sought to measure the gendered labor impacts of CA practices and to assess their feasibility in remote farming communities. We surveyed farmers in 3 tribal villages in the mid-hills of Nepal, where communities consist of smallholder (<2ha) farmers cultivating highly sloping, marginal lands. Face-to-face interviews and time allocation surveys were used to quantify distribution of labor and to identify engagement in agricultural decision-making in 87% of the households. On-farm plots were used to measure differences between the gender-based labor demands of conventional and CA practices. Results show that women bear a disproportionate burden (53–55%) of on-farm labor. Field trials showed that women would predominantly manage increases in labor demands from CA, particularly where more labor for plowing, sowing, and harvesting is required, yet 51.3% indicated that they have limited control over adoption of new practices. In situations where women are already overburdened, technologies that require additional labor may prove unsustainable. It is crucial to adapt technologies to provide gender-sensitive solutions and meet the needs of the local community. Identifying the gendered constraints of CA is vital to improving understanding of agricultural livelihoods.

3.2 Introduction

Population growth, soil erosion, and the effects of climate change (Beniston 2003) exacerbate challenges to sustainable food production and food security in rural, mountainous regions. To combat hunger and environmental degradation in developing countries, innovative technologies such as conservation agriculture (CA) have been introduced to improve crop systems and promote sustainable development. CA includes the practices of minimum tillage, intercropping, and the use of cover crops that help to mitigate soil nutrient depletion and land degradation and increase yields (Hobbs et al. 2008). CA was initially introduced for large-scale farms in developed countries, particularly the United States; however, it has been increasingly promoted in developing countries by various international agencies (Knowler and Bradshaw 2007). There are currently 72 million ha of CA systems worldwide, increasing at an average rate of about 7 million ha per year (Friedrich et al. 2012).

CA practices are especially beneficial on sloping lands prone to degradation and erosion and small, rain-fed farming systems with low inputs (Shrestha et al. 2004). Minimum tillage reduces the risk of degradation by minimizing soil disturbance and retaining soil structure. Field experiments have shown significant evidence that minimum tillage can reduce both runoff and soil loss (Tiwari et al. 2009). Intercropping with leguminous crops benefits soil fertility through nitrogen fixation, provision of soil organic matter, and added soil cover (Thapa 1996). Both practices require little capital for implementation, making them ideal for resource-poor households. However, the impacts of CA practices on household labor and their gender-related constraints and opportunities remain insufficiently studied.

This article argues for the utility of a feminist approach to understanding the costs and benefits of CA for smallholder farmers in developing countries, as labor demands and gender issues have been identified as constraints to the adoption of new agricultural practices (Lee 2005). Increasing interest in quantifying rural women's engagement in the agriculture sector is apparent with the development of indices such as the USAID Women's Empowerment in Agriculture Index and the Gender Empowerment Measure (Pillarisetti and McGillivray 1998). Feminist scholars have pointed out gendered effects of agricultural interventions and the need for gender sensitivity in development interventions, including conservation practices. In particular, feminist political ecologists have shown that a household is not a single harmonious unit, as is often assumed, but rather a place of power relations where women's voices tend to be subjugated (Rocheleau et al. 1996).

Of particular relevance to CA are feminist analyses of labor and time demands. One of the key insights in feminist theory is the notion of productive versus reproductive labor and how women often conduct the latter without being acknowledged. Reproductive tasks such as child-rearing and food preparation are typically carried out by women (Tancred 1995), while productive tasks include agriculture and are often shared by both genders. While both types of work are essential for livelihoods, reproductive work is often not considered or remunerated (Glenn 2001). This results in women shouldering a dual burden of productive and reproductive work, creating a gendered "time poverty" (Blackden and Wodon 2006). Particularly in rural subsistence communities, women have a high burden of labor due to this dual responsibility (Gurung et al. 2005). It is important to recognize the impact that interventions will have on this burden.

A new agricultural technique may change labor demands in significantly different ways for men and women. The distribution of household and agricultural labor plays a critical role in determining the feasibility of agricultural practices, as the inability to increase labor hours can be a factor in the failure to adopt practices despite their potential. Therefore, it is necessary to identify gender inequalities and labor demands at the household level (IFAD 2003). Moreover, equal participation in household decision-making is vital to improving the livelihoods of rural women, particularly in marginalized communities (Tulachan and Neupane 1999). However, there is a dearth of studies examining CA's gender-specific effects on workloads, its seasonal changes, and the dynamics of decision-making.

Analysis of CA and its impacts on smallholder farming communities in mountainous areas must consider the potentially uneven impacts of development interventions for men and women, as well as gendered distribution of household decision-making power. This article seeks to provide more detailed analysis of relations between types of CA practices and changes in the amount and types of labor than has been hitherto available. It aims to contribute in multiple ways. On a practical level, increases in labor requirements would hinder long-term adoption of CA despite its potential to increase food security, improve soil, and enhance livelihoods. On a policy level, if CA exacerbates the gender gap in time poverty, its blanket promotion in developing countries, particularly in erosion-prone regions, needs to be reconsidered. Furthermore, from a planning perspective, identified differences in costs and benefits of CA would strengthen the case for greater involvement of women in the design and implementation of CA-based projects.

3.2.1 Study area

More than one-third of Nepal's agricultural land is located in the central mid-hills, supporting 44% of the country's population of 29.8 million (Thapa and Paudel 2002). For this reason, it has become a major area of focus for improving food security. Much of the region's agricultural production is from subsistence farming; however, growing populations and deteriorating land have led to an increased need for improved agricultural technologies to increase soil conservation as well as crop yields. Local NGOs have been working to introduce improved cultivation methods, yet there exists a gap in research on the gender implications of such practices and how these may be beneficial or detrimental considering the distribution of labor. Research related to household dynamics in the mid-hills has shown that labor tends to be divided more evenly between the genders in resource-poor households; however, variation exists due to agroecological conditions, individual expertise, and ethnicity (Gurung et al. 2005). Many communities are highly influenced by traditional customs and Hindu patriarchal values (Bhushal

2008). Moreover, it has been documented that women in Nepal work significantly more hours than men, leading to physical and mental exhaustion (Pradhan and Shrestha 2010).

The *Chepang* people, who live in the mid-hill region (Figure 3.1), are an indigenous group identified as one of the most marginalized ethnic groups in Nepal in terms of geographic location and socioeconomic status (Luni et al. 2012). Villages are isolated on mountainsides without direct access to road networks and markets, limiting opportunities for income generation, and few if any receive agricultural extension services. While outmigration is prevalent in much of Nepal, this is not a viable option or common practice among the *Chepang* people (UN RCHCO 2012). These communities rely on rain-fed systems with few inputs and cultivate highly sloping, stony fields (Figure 3.2). Due to the topography, these areas are prone to erosion. Few *Chepang* households are self-sufficient in agricultural production, and food scarcity exists for approximately 6 months of the year (Piya et al. 2011). Insights about women's roles in agriculture in these communities may be relevant to similarly marginalized communities worldwide.

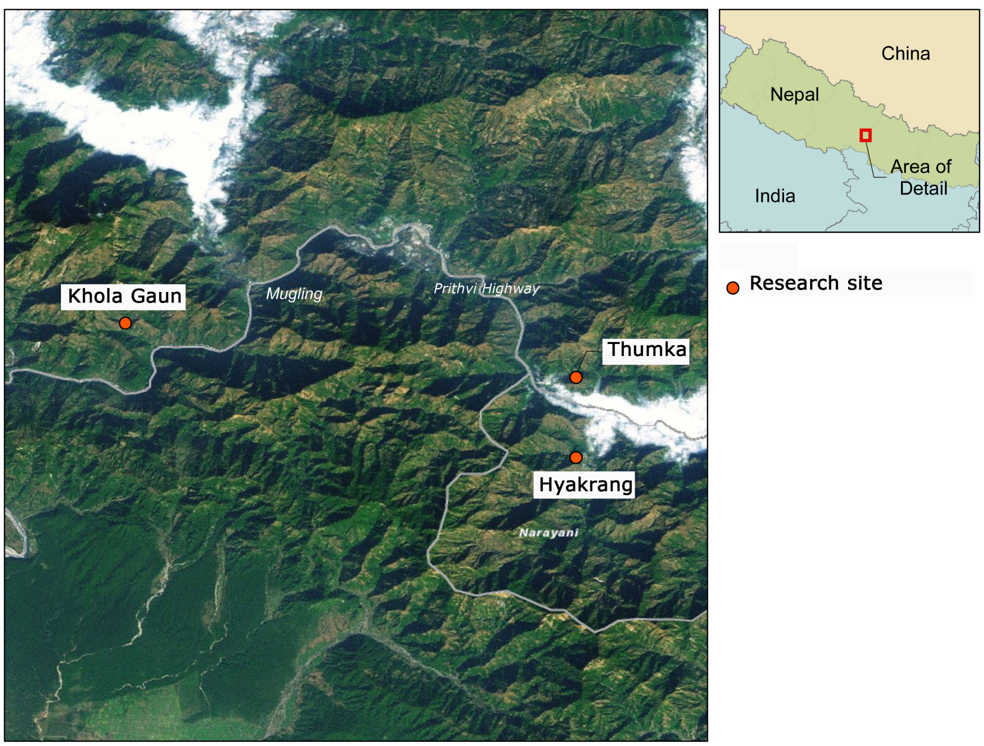

Figure 3.1. Map of study area.
(Map Data: Google, 2011; Map by Linsey Shariq)

Figure 3.2. Difficult farming conditions: (a) a Chepang farmer clearing maize stalks from a rocky field; (b) steep slopes in fields belonging to the Chepang study villages.
(Photos by J. Halbrendt)

The research took place in 3 villages—Thumka (Gorkha District), Hyakrang (Dhading District), and Khola Gaun (Tanahun District), with 42, 25, and 25 households, respectively. The villages are within the central mid-hill region with access by footpath to the nearest market of Mugling (latitude: 27° 50' 56" N; longitude: 84° 33' 03" E). These villages were selected due to their high risk for food insecurity from marginal, sloping agricultural lands and small landholdings. Agriculture in this area is characterized by subsistence farming, with less than 2 ha arable land per household and few opportunities for income generation. Farmers use continuous cultivation with terracing, draft plowing, and monocropping in a maize-based system.

3.2.2 Objectives

The objectives of this research were to (1) measure the gendered distribution of agricultural labor in the study villages, (2) estimate CA's likely effect on seasonal labor demands by gender, and (3) assess the implications of, and make policy recommendations for, optimizing the introduction of CA.

3.3 Methods

To quantify changes to the distribution of labor caused by CA, labor inputs for both traditional and CA practices were measured and compared. Since labor distribution varies at the local level, data were collected from individuals to develop an understanding of gender roles. Time-use surveys were used to estimate agricultural activities by gender and to measure the distribution of labor in the household and gain a better understanding of the adaptations made to accommodate changing practices (Beteta 2006). In June 2012, households in the 3 Chepang communities participated in an activities analysis (or time-use survey) that was differentiated by gender.

Men and women heads of household were surveyed separately in face-to-face interviews to assess gender participation and labor demands for 5 categories of livelihood activities: household, livestock, agriculture, off-farm, and community. Questionnaires assessed time spent on all daily and seasonal activities conducted in the household by measuring the months per year, days per week, and hours per day spent on each activity. This approach of quantifying months, days, and hours allows a more accurate elicitation of total time allocation using a recall approach. Recognizing the risk of recall error from this survey approach, a large sample (77 surveys, covering 83% of households) was surveyed. Agriculture and off-farm activities are seasonal, while household, livestock, and community activities occur throughout the year. Since only the labor inputs for agricultural activities are expected to change as a result of CA, these were the focus of analysis.

To estimate the impact of CA, the survey focused on 3 major crops: maize, millet, and legumes. Maize was selected for its importance as a staple crop, the capacity to integrate minimum tillage and intercropping, the soil and water conservation potential, and its benefits to food security. In a typical cropping season, maize is planted, followed by a relay leguminous crop around the time of maize harvest. The survey measured labor hours for conventional cultivation, representing a complete cropping season (conventional-tillage maize followed by legumes) at 5 stages: plowing, fertilizer application, sowing and transplanting, weeding, and harvest. On-farm experiments were conducted to measure labor shifts resulting from the introduction of 2 CA practices: intercropping (millet with cowpeas) and minimum tillage using a strip-till approach. Experimental plots were established on 8 representative fields in each village, and farmers' activities were recorded by gender for 2 CA treatments: (1) conventional-tillage maize followed by intercropped millet and cowpea, and (2) minimum-tillage maize followed by intercropped millet and cowpea. Changes in labor distribution were measured based on the difference in work hours between conventional practice and the 2 CA practices. Based on the data from the CA experiments, we calculated percentage changes in labor hours from the conventional practice to each of the CA practices.

These percentage changes were applied to the farm data for maize, millet, and legumes to calculate the changes to labor from CA in terms of hours at the whole farm level. This approach accounts for differences between the field size of the total farm and the smaller CA experimental plots.

A Likert scale was used to quantify self-reported feelings of control over decisions related to adoption of new agricultural practices. A range of no control, some control, equal control, a lot of control and total control was used to assess men's and women's engagement in agricultural decision-making. Focus groups and interviews were used to develop a seasonal calendar of livelihood activities, understand the cultural context and household dynamics, and validate the survey results.

3.4 Results

3.4.1 Changes in demand for labor with conservation agriculture

A total of 77 surveys (38 male, 39 female) were collected, comprising 83% of households. For the conventional farming practice, men conducted 46.9% of total labor and women 53.1%. For the CA practices (intercropping and minimum tillage/intercropping), a similar trend was maintained, with men completing 44.7% and 46.0% of total labor and women 55.3% and 54.0%, respectively.

Labor inputs were measured by gender for conventional and CA practices, and the percentage of increase or decrease was calculated for each (Figure 3.3). In all cases, shifting from conventional to CA practices led to greater total labor for women—2.17% in the case of intercropping and 0.91% in the case of minimum tillage and intercropping. Households with less labor availability were more likely to have an even distribution of labor between men and women for both conventional and CA practices.

Shifting from conventional to CA practices involved a distinct shift in labor requirements at different stages, with increases in plowing, sowing, and harvesting and decreases in fertilizer application and weeding for both genders. The increased labor for women in both CA treatments was largely in plowing and harvesting.

3.4.2 Seasonal shifts in time allocation

Total time allocation was calculated for 5 categories of livelihood activities (household, livestock, agriculture, off-farm, community). Data were analyzed using the mode as the measure of central tendency to reduce the influence of outliers. Women were found to perform 52.2% of total livelihood duties and men 47.8%, for an annual difference of 497 hours. Total waking hours can be estimated at 17 per day or 6,205 per year. Figure 3.4 shows the breakdown of annual time allocation by gender and category. For women, the most time is spent on household duties (48.7% or 2899 hrs/yr), with agriculture representing 21.4% (1274 hrs/yr) of time. Tending to livestock is the predominant activity for men (32.2% or 2070 hrs/yr), with 20.2% (1104 hrs/yr) of time spent on agriculture. Additional waking hours can be accounted for by personal free time and socializing activities.

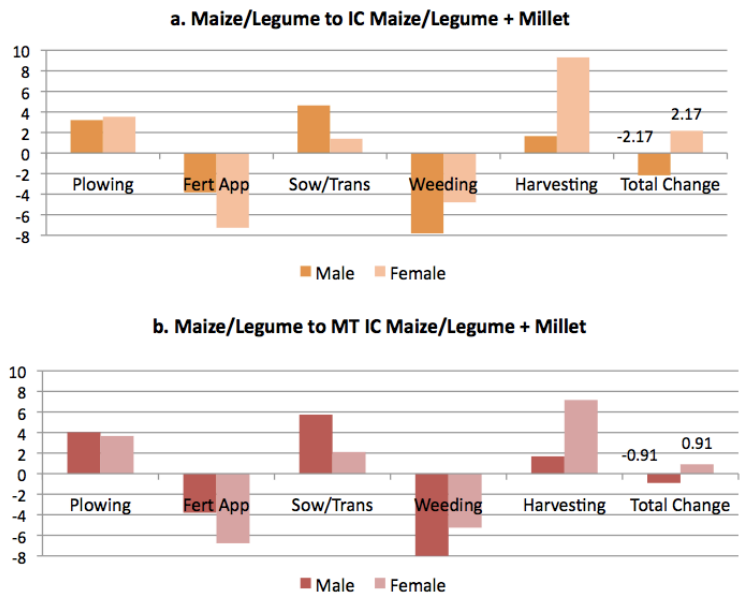

Figure 3.3. Percentage difference in labor inputs, by gender, between conventional and conservation agriculture practices.

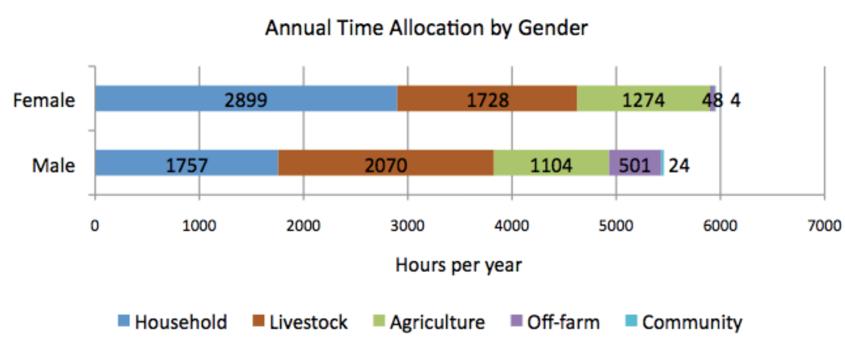

Figure 3.4. Annual time allocation of livelihood activities by gender.

Labor demands over the year were determined for each gender by calculating the seasonal agricultural and off-farm activities for each month and compiling them with the year-round household, livestock, and community activities. Figure 3.5 shows the different daily labor demands for men and women as they shift throughout the year. In some cases the hours spent per day exceed the waking hours. This can be attributed to activities that may occur concurrently, for example harvesting and childrearing (Figure 3.6). Nevertheless, all activities were calculated in the same manner for both genders and therefore reflect disparities in labor demands. Major increases in labor demands for both men and women occur from July to November, the primary growing season for millet, legumes, rice, and vegetables. Maize cultivation occurs earlier in the year, from January to August. Off-farm wage earning, primarily by men, occurs from November to February.

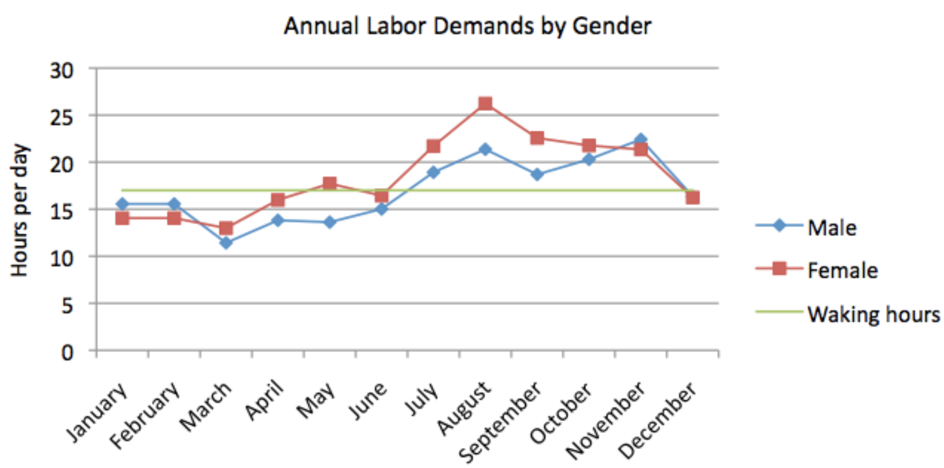

Figure 3.5. Monthly labor demands of livelihood activities by gender.
Hours per day exceed 24 in some cases due to concurrent activities (such as cooking and childcare).

Figure 3.7 shows the likely changes to labor requirements with the integration of CA. This was determined by applying the percentage change in labor from the experimental CA plots to the seasonal agricultural labor demands for each gender. The difference between results for the two CA practices (intercropping and minimum till with intercropping) was negligible for both men and women, less than 4 hours over the year. For this reason, the results of the 2 treatments were averaged in Figure 3.7 and will be discussed jointly. The greatest labor savings for both men and women are projected to occur in April and May, during plowing, fertilizing, and weeding of maize, and in September, during weeding and fertilizing of legumes. Women benefit more than men during these months, with labor savings of 10–15 hours per month. Over the same months, men show savings of 6.5–8.5 hours per month. Labor demands show the greatest increases during

July, the time of the maize harvest and plowing and sowing for millet and legumes, and during October and November, due to increases in harvesting of millet and legumes. Labor increases were shown to be more significant for women at this time, requiring 5.5–8 hours per month of additional labor. Over the same period, men's labor increased by 1–5.5 hours per month.

Figure 3.6. A Chepang woman processes maize while caring for her child.
(Photo by J. Halbrendt)

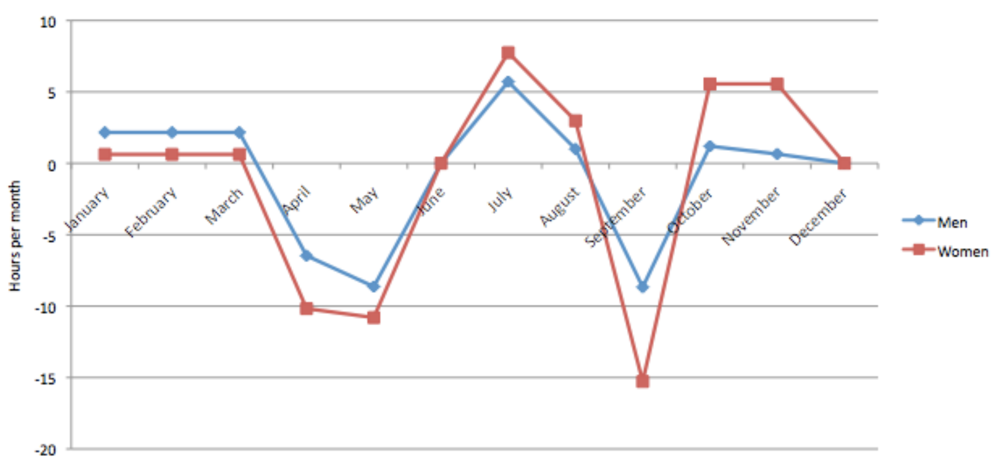

Figure 3.7. Projected changes to labor requirements from integration of conservation agriculture practices.
Positive values show increased labor demands, while negative values indicate labor savings.

3.4.3 Access to agricultural decision-making

The surveys of men and women heads of household measured self-reported engagement in decision-making regarding adoption of agricultural practices. The majority of survey respondents (60.5% of men, 46.2% of women) said they shared agricultural decision-making equally. Nevertheless, a number of men stated they had “a lot of control” (28.9%) or “total control” (15.8%) over decision-making, while a large proportion of women reported only “some control” (28.2%) or “no control/unsure” (23.1%). Interviews showed that household decision-making is highly influenced by patriarchal traditions, where men tend to make final decisions regardless of male or female tasks. This tended to be most prevalent where the heads of household were older and where women had less education. The most important factors for the hierarchy of decision-making were indicated as being male and older, though expertise and experience were also factors. Nevertheless, where men are not present due to off-farm obligations, it was often acceptable for women to lead decision-making. Some households had clear delineations for control over decision-making, with male tasks decided by men and female tasks by women.

3.5 Discussion

3.5.1 Impact of conservation agriculture on labor demands

From the analysis, it is evident that women carry out a greater proportion of agricultural labor, which increases with the addition of CA. Overall, while men manage plowing, women conduct the majority of fertilizer application, weeding, and harvesting. While sowing and transplanting were predominantly women’s tasks in conventional farming practices, the work was more evenly distributed between men and women in the CA practices, where time required for sowing increased due to intercropping. Both CA options showed a total increase in labor for women; however, the shift from conventionally grown millet to minimum tillage/intercropping created less of an increase (0.91% compared with 2.17%). Physically tasking activities such as weeding are also reduced with this practice. Though the labor difference is slight, this decrease in more physically demanding activities can reduce some of the physical burden on women (Pradhan and Shrestha 2010). For men, both practices reduce total labor, and shifting to an intercrop-only practice creates a greater reduction.

Increased demands for plowing with CA can be attributed to the use of hand tools rather than conventional draft plowing, which is men’s work, while increased harvesting requirements may be due to the second crop introduced through intercropping. While increased harvests can lead to greater food security and income, they also increase the demand for post-harvest processing, which was not measured in this study. Though overall labor demand increases from CA are small, they could inhibit its long-term use, given other labor demands such as reproductive work. For this reason, it is important to assess the CA-related changes within the context of total labor requirements, as heavy existing workloads may prohibit the adoption of practices that require increased labor. Conversely, reduced demands for labor may allow the diversification or improvement of other agricultural fields, as well as increased time for off-farm activities.

In focus groups, interviews, and farmer preference studies, farmers have indicated that increasing yields and income are high priorities. Given the existing food scarcity, there is clearly a need for new cultivation methods. However, any solutions will have to involve labor demands that are feasible.

3.5.2 Implications of seasonal shifts in time allocation

The most labor-intensive agricultural season, during which farmers would benefit most from labor-saving practices, is July–November, with labor demand exceeding 17 waking hours per day. The potential labor savings from CA are greatest during weeding and fertilizing of legumes, with approximately 15 fewer labor hours/month for women and 8.5 fewer hours/month for men. This presents a high potential benefit for farmers, especially women, as these are some of the most physically taxing components of cultivation (Pradhan and Shrestha 2010). However, increased labor demands during harvest and plowing for intercropping, when existing labor requirements are already high, may create a barrier to adoption of CA practices. The increases in labor for sowing under CA are shared by men and women; however, the majority of the increased harvesting demands fall to women. This may be attributed to men’s involvement in cultivation being higher at the start of the cropping season and tapering later in the season. Introducing efficiencies during sowing and harvesting may reduce the overall labor requirement and make CA feasible. These may include determinate crop varieties, which may have more uniform growth patterns, and cultivation methods to regulate crop height, a streamlined harvesting process, or hand tools designed for efficient line planting.

3.5.3 Impact of access to agricultural decision-making

While many households report equal involvement in agricultural decision-making, 51.3% of women reported having less control than their male counterparts. As reported in individual interviews, this could be attributed to cultural expectations of male-dominated decision-making and feelings of inferiority by women who lack education. While participation in agricultural decision-making tended to vary from household to household, the overall trend was to defer to the male head of household for final decisions. Given that women conduct the majority of farm labor and will experience increased labor from CA, women's lack of input on adoption may result in decisions that do not consider its practical feasibility, creating a barrier to long-term implementation.

3.6 Conclusions

As evidenced in this study, CA practices can have varying effects on labor demands. Such changes can result in an inequitable or impractical redistribution of labor between men and women; thus, it is crucial to assess the gender impacts and feasibility of introduced practices. These changes are likely to be locally specific, depending on culture and environment. Nevertheless, the framework provided here could be used to measure potential labor shifts in other mountain regions where smallholder farms are common.

Additionally, one should consider this research within the larger household and community context. Other agricultural activities and household obligations may restrict the capacity to absorb the shifts in labor that would result from adopting CA. A practice that causes little or no change to labor demands can be more feasible, particularly where existing labor demands are high.

Seasonality of labor demands is another important factor affecting the feasibility of a practice. Finally, opportunity costs in terms of potential for off-farm wage earning are important to consider in the overall benefits of agricultural labor saving. Further research should investigate the sociocultural determinants of agricultural division of labor and the dynamics of decision-making to better understand communities' adaptability to changing agricultural systems.

The results demonstrate that CA's benefits are contextual and may benefit some more than others. Given the gendered pattern of labor and decision-making power, this calls for an intentional involvement of women in the execution of CA projects. If CA is adopted without consideration of women's workloads and other concerns, it runs the risk of demanding more labor from women who are already overworked and physically exhausted. As women tend to shoulder much of the reproductive work in the household, the additional time requirement for them may result in a tradeoff between agriculture and vital household responsibilities, including preparation of food. In the long run, not only is participation by women in the design and implementation of CA projects important in and of itself as a way to achieve gender justice, but equal participation in household decision-making is a critical part of improving the livelihoods of rural women (Tulachan and Neupane 1999).

In sum, this research has demonstrated the importance of integrating gender sensitivity and an understanding of gender-based agricultural division of labor in the planning process for agricultural development projects, to promote both community equity and increased adoption. Policy-makers and development practitioners must apply an interdisciplinary approach, considering the gender, economic, and environmental impacts of introduced practices to develop practical approaches and better understand farmers' conditions. With continued work in this area, projects can be better designed to consider gender dimensions and improve long-term development.

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Chapter 4. Assessing the socio-economic determinants for adoption of conservation agriculture practices among smallholder farmers: A case study in the mid-hills of Nepal

4.1 Abstract

Limited adoption of introduced agricultural practices has led to increased interest in the study of the underlying factors related to farmer decision-making and the socio-economic aspects that may contribute to an individuals' willingness to adopt new practices. This research identifies farmers' characteristics and likelihood of conservation agriculture adoption as a function of a series of farmer characteristics that include both tangible (e.g. farm size, household labor capacity, available labor resources, income) and intangible (e.g. agricultural experience, degree of trust) dimensions of agricultural decision-making. Surveys were conducted through face-to-face interviews with farmers in two rural, subsistence-farming communities. A Logit regression model was used to determine the relevant farmer characteristics that contribute to adoption or non-adoption of conservation agriculture technologies. This research can be applied to develop locally adapted implementation strategies and improve planning for conservation agriculture projects.

4.2 Introduction

With rising populations and food insecurity, there is a subsequent shift towards the cultivation of marginal land by smallholder farmers, particularly in areas where limited arable land is available. In the case of Nepal, such marginal lands tend to be highly sloping and prone to erosion and accelerated soil degradation (Shrestha et al. 2004). This calls for improved land management strategies, such as the increased implementation of conservation agriculture (CA) practices, to mitigate the effects of degradation and improve the long-term productive capacity of the land. CA applies the principles of minimum soil disturbance, permanent soil cover, and crop rotations to reduce land degradation, improve crop yields, and promote sustainable agricultural systems (Hobbs et al. 2008; FAO 2014). Due to its relatively low implementation costs and potential for improving food security, CA has been promoted by various donor organizations in developing countries as an approach to improve the agricultural system and livelihoods of farmers (Knowler and Bradshaw 2007). However, those introducing CA practices have faced challenges in establishing long-term adoption.

Globally, there are more than 500 million smallholder farms, generally defined as having less than 2 ha of land per household (IFAD 2011). These households comprise the majority of the world's poor and are characterized as highly vulnerable to food insecurity and environmental change. With few technical and financial resources available, these households often struggle to adapt to changing climates and to maintain sufficient crop productivity (Shang 2014). In Nepal, where 80 percent of the population comes from smallholder, subsistence farms and 70 percent of farms are less than 1 ha in size, the plight of the rural poor is further exacerbated. The country's remote communities and rugged terrain limit access to markets and extension services, inhibiting economic development, while climate shifts in the form of drought and erratic rainfall contribute to reduced yields and food scarcity (IFAD 2014). These areas are prime for interventions such as CA, requiring few input costs while decreasing degradation and improving yield, yet historical evidence shows that introduced practices are often abandoned following the completion of development projects (Bunch 1999; Cochran 2003; Yadav 1987). Thus, in order to develop effective conservation outputs, it is important to understand the dynamics of farmer decision-making for introduced CA technologies.

Implementing conservation practices can be an inherently difficult process, as the mitigating effects of reduced erosion and degradation are often not observable for many years and may show variability in terms of positive, negative, or neutral impacts during the initial years of CA integration. Furthermore, CA provides many indirect benefits via soil fertility and water conservation improvements. The delayed benefits of CA work in contrast with the relatively short time horizon of subsistence farmers, who often must make decisions based on the current season's yield (Giller et al. 2009). This can result in lower adoption rates, as farmers' livelihoods and household food security are dependent on the capacity to produce viable and sufficient outputs from year to year. Identifying and understanding the complex socio-economic characteristics of farmers who may be willing to adopt or not adopt new conservation practices will be vital for developing community-focused approaches for the improved implementation of CA systems, addressing the needs of both the farmer and the environment.

The factors that determine adoption are highly contextual, based on local environmental and socio-cultural conditions at the community level (Halbrendt et al. 2014); however, in terms of farmers' adoption decisions, there are also a number of characteristics that play a role at the individual level. Adoption of agricultural technologies, particularly for developing countries, depends on a wide range of factors, including: socio-economic aspects of the individual farmer and household, physical characteristics of the farm, and access to resources (Kebede et al. 1990). It can be assumed that the farmer weighs the comparative advantage of a new technology against her or his capacity to implement the technology and the willingness to absorb the risk of decreased crop production (Tiwari et al. 2008). The logistic regression model used in this study identifies the relevant farmer characteristics involved in the decision-making process and explores the interactions of those characteristics in terms of adopting CA practices. The specific objectives of this research were:

I. To determine the significant socio-economic factors contributing to individual farmers' likelihood of adoption for introduced conservation agriculture technologies
II. To assess the major constraints leading to non-adoption of conservation agriculture technologies
III. To identify the implications for conservation agriculture approaches and develop policy recommendations

4.2.1 Study Area

The focus of this study was in the central mid-hills of Nepal, an area that supports 44% of the country's population and is highly dependent on smallholder farming. This area has been identified as a high priority for agriculture development to improve food security and mitigate the effects of climate change (Thapa and Paudel 2002). In recent decades, increasing populations have led to a transition from shifting cultivation to intensified, continuous cultivation of marginal, highly sloping land, resulting in a need for improved agricultural technologies to increase soil conservation and crop yields.

This research was conducted in two rural *Chepang* villages in the mid-hill region, Khola Gaun (Tanahun District) and Thumka (Gorkha District) (Figure 4.1). These communities were selected for participation in this study based on past and present engagement with a local NGO in conservation projects, as well as their high risk of food insecurity and limited opportunities for income generation. The two villages are comparable in terms of ethnic group, economic status, farm size, and farming practices. The *Chepang* are indigenous to Nepal and are one of the most marginalized ethnic groups in terms of geographic location and socio-economic status (Luni et al. 2012). The villages predominantly consist of subsistence farming households and are located on the mountainside, lacking direct access to road networks and markets. The isolation of these villages limits opportunities for off-farm income generation as well as access to agriculture extension services. Farming in this area traditionally consists of a maize-based system on terraced land using sole cropping of local crop varieties, continuous cultivation, and draft plowing. However, the practices of conventional tillage, relatively low inputs of fertilizer, and leaving land fallow in the dry season have slowly degraded the land quality and increased the vulnerability to erosion. It has been estimated that food scarcity exists for approximately six months of the year in *Chepang* households and few are self sufficient in agricultural production (Piya et al. 2011).

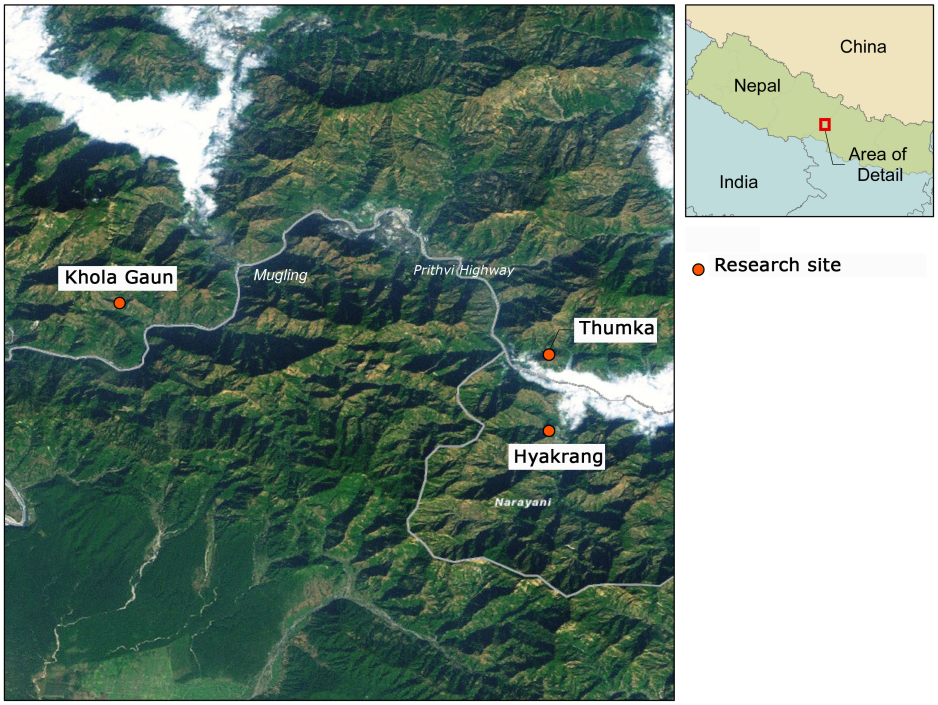

Figure 4.1. Map of Study Area, Central Mid-hills, Nepal.
Latitude: 27° 50’ 56” N; Longitude: 84° 33’ 03” E (Coordinates for central market at Mugling).

4.3 Methodology

To determine the significant characteristics for identifying adopters and non-adopters of CA practices, a binomial logistic regression model was developed. This method was selected due to its capacity for incorporating multiple independent variables and its potential to determine the degree and direction of influence each variable has on a dependent variable (Tiwari et al. 2008). The model incorporates a dichotomous dependent variable, adoption or non-adoption of an introduced CA practice, and 12 explanatory variables from the literature to identify the significant contributing factors in the adoption decision. The explanatory variables are categorical or continuous. Past studies were used to develop a hypothesis for each of the explanatory variables to predict the direction of influence (+/-) on adoption. A summary of the variables and their hypotheses are shown in Table 4.1.

Theoretical Logit Model Equation:

$$Y_i = \beta_0 + \beta_1 AGE_i + \beta_2 GENDER_i + \beta_3 EDUCATION_i + \beta_4 TRUST_i + \beta_5 INCOME_i + \beta_6 FARMSIZE_i + \beta_7 LABOR_i + \beta_8 FOODSECURITY_i + \beta_9 INFORMATION_i + \beta_{10} EXPERIENCE_i + \beta_{11} ENVIROCONCERN_i + \beta_{12} LANDTENURE_i + \varepsilon_i$$

Table 4.1. Summary of variables in the Logit model

Variable	Definition	Predicted direction of influence
Dependent variable		
Y_i	1 = ADOPTER, has implemented hedgerow technology on farm 0 = NON-ADOPTER, has never implemented hedgerow technology on farm	
Explanatory variables		
Farmer characteristics		
AGE	Age of farmer in years	-
GENDER	1 = Female, 0 = Male	-
EDUCATION	Years of formal education completed	+
TRUST	Index of trust in NGO staff, projects, and expertise	+
Resource/economic characteristics		
INCOME	Total on- and off-farm annual household income	+
FARMSIZE	Total hectares of farm	+
LABOR	Number of adult household members contributing to agricultural labor	+
FOODSECURITY	Household Food Insecurity Access Scale	-
INFORMATION	Level of interaction with agriculture extension or NGOs in past 2 years: 0 = none/low, 1 = moderate, 2 = high	+
EXPERIENCE	Number of years involved in farm decision-making (shared or total control)	+
ENVIROCONCERN	Index of farmer perception of environmental degradation and need for conservation	+
LANDTENURE	1 = owns land title, 0 = does not own land title	+

Face-to-face interviews were conducted with the primary male or female heads of household in the two *Chepang* villages. A total of 56 surveys were conducted in March 2014, representing 82% of total households. The surveys included questions to assess the dependent adoption variable and explanatory variables for individual farmer characteristics and farm/resource characteristics. All data was analyzed using SPSS statistical software (IBM Corp. 2013). For variables using an index (TRUST, FOODSECURITY, ENVIROCONCERN), a Cronbach's alpha internal consistency analysis was conducted to determine if it is justifiable to aggregate the responses for a suite of related questions (Cronbach 1951). Questions found to reduce consistency (contributing to a Cronbach's alpha value <0.7; George and Mallery 2003; Tavakol and Dennick 2011) were considered unacceptable and removed from the respective index.

Next, a stepwise regression using a bidirectional elimination approach was conducted to assess the fit and appropriateness of each explanatory variable in the model and to analyze the influence of the explanatory variables on the dependent adoption variable. While the appropriateness of using a stepwise approach is often debated, citing statistical bias and data mining (Whittingham et al. 2006), in cases where the study population has been under-researched or the existing literature is not inclusive of the study demographic, there is justification for using this approach to test the validity and fit of the variables. Moreover, in areas where large data samples are not possible, as is often the case with remote, rural villages, it is important to understand the interaction effects of the independent variables and ensure that data anomalies such as outliers and collinearity are not adversely impacting the precision of the model (NCSS). The adjusted Logit model was then run to determine the significance and direction of influence for each of the remaining explanatory variables.

4.3.1 Dependent variable

Implementation of hedgerow technology was used as a proxy for the adoption of CA practices. A local NGO (Local Initiatives for Biodiversity Research and Development, Pokhara, Nepal) worked with the study communities to introduce and provide technical assistance for hedgerow technologies from 2002-2005. At the time of the project, the NGO provided an equal opportunity for all households to participate in trainings, view demonstration plots, and receive seeds for implementation. The adoption of this technology over the subsequent years can be used to measure actual adoption outcomes (and delineate adopter and non-adopter groups) following multiple years of intervention and the completion of the NGO's active involvement. The use of this proxy variable is analogous for consideration of CA adoption due to the overlap in conservation goals, namely mitigating soil erosion and improving soil and water conservation on the farm (Sharma 2013). Moreover, both hedgerow and CA technologies have similar requirements in terms of minimal required inputs, primarily initial seeds and additional labor. While it is recognized that hedgerow technologies address slightly different concerns in terms of soil and water conservation and the agricultural landscape as compared with CA, nevertheless, this approach allows for the tangible characterization of adoption for an interrelated practice. In the model, this variable is defined as binary, with a value of 1 for respondents that have implemented hedgerows on their farm at any time since the training was provided (ADOPTERS), and a value of 0 for respondents that have never implemented hedgerows on their farm (NON-ADOPTERS). Since the survey did not explore the reasons why individuals may have stopped using hedgerows, any individual that took the initiative to implement hedgerows at any point were included in the adopter group.

4.3.2 Explanatory variables

The explanatory variables cover a broad range of factors that have been identified as contributing to the likelihood of adoption of CA practices. Characteristics of the individual farmer are evaluated using the demographic variables of age, gender, and education, as well as the latent variable of trust in NGOs. Access to resources and economic variables include: income, farm size, agricultural labor, food security, access to information, farming experience, concern over the environment, and land tenure. The relevance of each of these variables to the model is described in further detail below.

AGE

Measured as a continuous variable, increasing age is expected to negatively affect adoption. Older age can be associated with a decreased likelihood of benefitting from long-term conservation efforts, discouraging adoption (D'Souza et al. 1993, Bohlen et al., Neupane et al. 2002). In contrast, younger household heads are expected to be more willing to innovate and have more time to accrue CA's long term benefits, thus would be more likely to adopt (Stark 1996, Daberkow and McBride 1998).

GENDER

A categorical variable, it is expected that women are less likely to adopt conservation practices due to disproportionate burdens of household and agricultural labor (Lubwama 1999). Additionally, due to persisting patriarchal traditions and often less engagement of women in trainings, women may have less access to or awareness of introduced technologies (Tiwari et al. 2008).

EDUCATION

A continuous variable measured as years of formal education completed, it is expected that more education will lead to an increase in adoption. An assumed linkage of education with knowledge and less conservative behavior may result in the higher likelihood of adopting new technologies (D'Souza et al. 1993, Stark 1996, Bohlen et al., Knowler and Bradshaw 2007, Tiwari et al. 2008).

TRUST

An index consisting of 12 questions was developed to measure the level of trust in NGO staff and projects. Questions were derived from the literature and assessed farmers' perceptions of NGO projects in terms of expertise, values, benefits, and reliability. A low index score signifies less trust in NGO staff and is expected to correlate with decreased adoption (Bohlen et al.).

INCOME

Higher income can be associated with more financial stability and a greater capacity to absorb the risks of adopting a new agricultural practice. Therefore, it is expected that higher income households will not only be more likely to adopt, but will be among the early adopters of new technologies (Bohlen et al., Kebede et al. 1990, AFT 2013, Daberkow and McBride 1998, Knowler and Bradshaw 2007, Tiwari et al. 2008).

FARMSIZE

Similar to higher income, it is proposed that larger farms can better absorb the risks of adopting new practices and are associated with increased adoption (Bohlen et al., Kebede et al. 1990, AFT 2013, Daberkow and McBride 1998, Tiwari et al. 2008).

LABOR

A continuous variable indicating the number of adults contributing to household agricultural labor, it is expected that increased labor availability will correlate with increased adoption, an increase in adoption is expected (D'Souza et al. 1993, Stark 1996).

FOODSECURITY

This variable was measured using the Household Food Insecurity Access Scale (HFIAS), a widely accepted index comprising 9 questions related to household food availability, quantity, and diversity over the past month (Coates et al. 2007). While scores may differ depending on season when the scale is measured, the results will nevertheless indicate a measure of food security relative to others in the same study community. A higher score indicates greater food insecurity (max score=27), and is expected to have a negative correlation with adoption. Low food security may limit adoption due to enhanced sensitivity to short-term production losses (Shively 2001).

INFORMATION

This categorical variable was measured as the level of interaction with external sources of agriculture information and technology. A frequency distribution of the number of interactions with either NGO or agriculture extension officers over two years was used to define categories of none/low, moderate, or high levels of access to external sources of information. It is expected that greater access to information increases the likelihood of adoption (Bohlen et al., Kebede et al. 1990, AFT 2013, Daberkow and McBride 1998, Knowler and Bradshaw 2007). Similarly, a lack of access to information and technical support systems may result in decreased adoption (USDA NRCS 2005).

EXPERIENCE

Measured as the number of years engaged in on-farm decision-making, it is expected that more experience with farm management provides confidence and skills that will increase the likelihood of adoption (Kebede et al. 1990; USDA NRCS 2005).

ENVIROCONCERN

Environmental concern was measured as a 12-question index to assess farmers' levels of awareness and concern regarding their crop yield, soil erosion, and water availability. The questions were derived from concerns expressed in the literature regarding sloping land cultivation. A high score in the index indicates increased awareness of local environmental conditions, which is expected to correlate with increased adoption of conservation practices (D'Souza et al. 1993, Knowler and Bradshaw 2007). Similarly, a lack of awareness of erosion can result in non-adoption of mitigating practices (Stark 1996, USDA NRCS 2005, AFT 2013).

LANDTENURE

Measured as a categorical variable, land tenure indicates whether the household holds a government-recognized land title. Evidence has shown that, lack of secure ownership of farmland acts as a disincentive for adoption and farmers are less likely to invest in long-term conservation efforts (Stark 1996, Cox 2011, Knowler and Bradshaw 2007, Lee 2005).

4.4 Results and discussion

4.4.1 Cronbach's alpha analysis for latent constructs

Three of the explanatory variables used an index to measure latent constructs: TRUST, FOODSECURITY, and ENVIROCONCERN. Since these variables cannot be measured directly, a set of questions was developed to identify potential indicators and assign a numerical value to these latent constructs. In the case of FOODSECURITY, the well-established Household Food Insecurity Access Scale was implemented. For measuring TRUST and ENVIROCONCERN, questions were derived from the literature and locally adapted based on preliminary studies of the research area and communities. A Cronbach's alpha analysis for each index further refined these questions based on internal consistency measures. For FOODSECURITY, the analysis showed high internal consistency with a Cronbach's alpha value of 0.904. This falls into the acceptable range of 0.70-0.95 (Tavakol and Dennick 2011). Since the food security index is has been vetted and is a widely accepted measure, this internal consistency is to be expected (Coates et al. 2007). The initial Cronbach's alpha coefficient for TRUST was 0.594, falling outside of the acceptable range; however, the analysis showed that 3 of the 12 questions were reducing consistency of the index. These questions, which were in regards to generalized trust in all people, as opposed to NGOs, were removed from the index. This resulted in an improved Cronbach's alpha coefficient of 0.694. While this is slightly out of Tavakol and Dennick's (2011) acceptable range, other researchers have indicated that values above 0.6 and approaching 0.7 may still be considered acceptable (George and Mallery 2003), particularly in cases where data samples are small.

For ENVIROCONCERN, the Cronbach's alpha coefficient was 0.454, with no distinct questions reducing the consistency of the index. This inconsistency may be due to combining the topics of yield, erosion, and water availability in the same index, resulting in low overall correlation. A few independent questions showed significant correlation with the adoption variable (Table 4.2); however, as an index, these were not comprehensive enough to represent an individual's general level of concern over environmental degradation. The correlation test showed concern regarding the condition of the local environment among the adoption group (N=41), as a large proportion saw the need for improved cultivation practices, water systems, and increased water availability for crops. Nevertheless, since the analysis showed internal inconsistency, and the individual questions could not accurately represent the latent construct, the ENVIROCONCERN index was removed as a variable from the Logit model.

Table 4.2. Correlation of environmental concern variables and adoption

Environmental Concern	Pearson Correlation	Significance (1-tailed)	Adopters (N)	Non-Adopters (N)
Observed change in soil erosion	-0.242	0.036[b]	9	7
Cultivation practices impact crop yield	0.363	0.003[a]	34	7
Need for improved water systems	0.235	0.041[b]	39	12
Need for increased water availability for crops	0.302	0.012[b]	40	12

[a] Significant at the 0.01 level
[b] Significant at the 0.05 level

4.4.2 Descriptive statistics

The descriptive statistics of the explanatory variables (Table 4.3) give a general overview of the characteristics for adopters and non-adopters of hedgerow technologies. From the survey population (N=56), 73% of respondents had adopted hedgerow technology at some point, with the remaining 27% characterized as non-adopters. Due to this disparity in distribution of cases between adopter and non-adopter groups, some of the means may be falsely skewed due to the high/low number of cases in the group and may not accurately represent adopter or non-adopter characteristics. Nevertheless, analysis of the logistic regression will determine the significant variables in the model.

4.4.3 Stepwise regression results

The results from the stepwise regression showed that the explanatory variables of LANDTENURE and EXPERIENCE were not significant ($p<0.1$) and did not substantially contribute to the model. LANDTENURE had low correlation with the other variables and resulted in marginal changes when removed from the model, therefore was excluded from the Logit analysis. This may be attributed to the relatively short time period in which land ownership has been a common practice for the *Chepang*. Until a few generations ago, the *Chepang* were known to be semi-nomadic, practicing some shifting cultivation, however, subsisting primarily by foraging in the forest. Furthermore, the *Chepang* have historically been excluded from formal land ownership processes, relying on customary and oral traditions for land use and management, so they may not place the same weight on land titles as those in urban areas (Sharma 2011). In the analysis of the EXPERIENCE variable, it was determined that this was highly correlated ($p<0.05$) with the AGE variable, resulting in a multicollinearity effect. Since age and experience can be considered analogous to one another, and farming experience essentially begins at childhood in the study areas, the EXPERIENCE variable was omitted from the final model.

4.4.4 Logit regression model results

With the exclusion of the variables ENVIROCONCERN, LANDTENURE, and EXPERIENCE resulting from the prior analyses, the adjusted Logit model equation includes nine explanatory variables. A binomial logistic regression was conducted to determine the direction and level of influence for each of the remaining explanatory variables (Table 4.4).

Table 4.3. Descriptive statistics of variables used in the Logit model

Variable	Population (Mean)	Adopters (Mean)	Non-adopters (Mean)
Dependent variable			
Y_i	N=56	N=41 (73%)	N=15 (27%)
Explanatory variables			
Farmer characteristics			
AGE (years)	37.8	39.2	34.3
GENDER[a]	0.41	0.39	0.47
EDUCATION (years)	1.8	1.4	3.0
TRUST[b]	6.5	6.7	5.7
Resource/economic characteristics			
INCOME (1000 NPR)	87.15	83.95	95.88
FARMSIZE (ha)	0.37	0.40	0.26
LABOR (no. people)	3.9	3.9	3.7
FOODSECURITY[c]	9.0	8.2	11.1
INFORMATION[d]	1	1.1	0.9
EXPERIENCE (years)	11.4	13.3	6.4
ENVIROCONCERN[e]	7.5	7.6	7.1
LANDTENURE[f]	0.8	0.8	0.8

[a] Values approaching 0 indicate a higher proportion of men, values approaching 1 indicate a higher proportion of women
[b] Higher values indicate greater levels of trust, Max value=9
[c] Higher values indicate greater food insecurity, Max value=27
[d] Values assigned as 0=none/low, 1=moderate, 2=high
[e] Higher values indicate more concern over environment, Max value=12
[f] Values approaching 0 indicate less land title ownership, values approaching 1 indicate more land title ownership

Adjusted Logit Model Equation:

$$Y_i = \beta_0 + \beta_1 AGE_i + \beta_2 GENDER_i + \beta_3 EDUCATION_i + \beta_4 TRUST_i + \beta_5 INCOME_i + \beta_6 FARMSIZE_i + \beta_7 LABOR_i + \beta_8 FOODSECURITY_i + \beta_9 INFORMATION_i + \varepsilon_i$$

The logistic regression to determine farmer characteristics for adoption of CA practices was statistically significant, explaining 29.9% to 43.4% (Cox & Snell R^2 and Nagelkerke R^2, respectively) of the variance in adoption. The model correctly classified 81.8% of cases. The results of the analysis showed the factors EDUCATION, INCOME, and FOODSECURITY as significant at the 5% level, with the variables AGE, GENDER, and TRUST were significant the 10% level. FARMSIZE, LABOR, and INFORMATION were somewhat correlated with the model, however, were not significant.

4.4.4.1 Farmer characteristics

Each of the farmer characteristics (AGE, GENDER, EDUCATION, TRUST) was found to be significant in the Logit model. While EDUCATION was highly significant (p<0.05), the direction of influence had an opposite sign from the hypothesis. The data for EDUCATION shows that more than 53% of respondents indicated having had no formal education, and only one respondent had more than six years in school. Due to the high number of cases with 0 years of education, the skewed distribution of data could have affected the directionality of the variable in the model. Nonetheless, much of the literature with positive correlations between education and higher rates of CA adoption considers areas, such as North America, where access to more than a primary level of education is standard (D’ Souza et al. 1993; Knowler and Bradshaw 2007). However, there have been other cases in the developing world that have shown a negative correlation of education and adoption (Gould et al. 1989; Okoye 1998). In this case, more education showed a decreased willingness to adopt CA such that with every additional year of education, farmers were 0.57 times less likely to become adopters of CA. This result is a reflection of the relatively low levels of access to both primary and secondary education. Moreover, due to the subsistence nature of the study communities, education is often a tradeoff for meeting immediate agricultural and household labor demands (Tryndyuk 2011). This effect could also be a function of less education leading to greater levels of reliance on external sources of information, such as Non-Governmental Organizations, and a greater willingness to adopt introduced agriculture practices. This signifies that there is a distinction between formal and informal education in terms of adoption. Formal education is a departure from the applied knowledge gained from agricultural trainings and other community-targeted education programs and may not provide the practical skills needed for subsistence livelihoods. For the other farmer characteristic variables, the hypotheses were correct, with the model confirming that younger, male farmers, and those with high levels of trust in NGOs were associated with an increased likelihood of adopting CA.

The significance of the TRUST index, including indicators of NGO values, expertise, and accountability, highlights the importance of the relationship between an NGO and the local community. The transfer of new knowledge is reliant on whether the information comes from a trustworthy social network (Carolan 2006), resulting in a strong interconnection between trust, knowledge, and application of that knowledge (i.e. adoption of introduced practices). Furthermore, trust is created through a history of relational experiences and therefore must be built and maintained over time through a series of interactions (Hardin 2001).

4.4.4.2 Resource/economic characteristics

Both FOODSECURITY and INCOME were strong indicators ($p<0.05$) of adoption in the Logit model. The results showed that higher levels of food security (indicated as low food insecurity in the HFIAS index) correlated with a willingness to adopt CA, which supports the initial hypothesis. However, the variable for INCOME showed another anomaly where the variable was highly significant, yet the direction of influence contrasted with the hypothesis. The data for income showed a wide range of values, from less than 500 NPR (5.09 USD) to almost 300,000 (3043 USD), though the average household income was 87,150 NPR (887 USD). The households with higher incomes were earning the bulk from sales of livestock and off-farm wage earning, with a small proportion of households (16%) receiving remittance from family members who have migrated for work. A study of *Chepang* communities showed that remittance and skilled non-farm jobs were the most remunerative sources of income, however, few households had the resources to take advantage of such opportunities (Piya et al. 2011). This indicates that, as households gain the potential to earn more income through livestock or off-farm activities, they may become less invested in improving the cultivation of crops. Furthermore, among those with access to off-farm income generating opportunities, the economic benefits of soil conservation efforts may not be large enough to justify investments in CA integration (Gould et al. 1989).

FARMSIZE was shown to be insignificant in the model. The descriptive statistics show that the largest farm was 1.65 ha with an average farm size of 0.37 ha. All the farms in the study fall within the designation of smallholder, thus even the largest farm in the villages does not have much of a comparative advantage in terms of excess land. LABOR was another factor that was insignificant. In this case, the availability of labor did not significantly impact the willingness to adopt CA. One aspect of labor that was not reflected in this model was the frequent use of exchange labor on farms in these communities. This unmeasured component of labor availability may be the reason that limited household labor is not indicated as a significant factor when considering new agricultural practices that would likely require additional labor. INFORMATION was not found to be significant in that greater access to sources of agricultural information did not correlate with higher rates of adoption. As described above, TRUST in NGOs was a positive indicator of adoption, yet greater access to NGO or extension staff did not result in significant levels of adoption. This signifies a possible disconnect between the intentions of NGO projects and their implementation. However, the inclusion of agriculture extension in the access to INFORMATION variable also contributes to the lack of influence on the model. Agriculture extension services in the *Chepang* villages are often infrequent and, due to government policies restricting cultivation in the mid-hills, do not always have share the same values and goals as the farmers. In sum, with regards to resource and economic characteristics, adopters of CA practices have been identified as likely to have higher food security, though with moderate to low household incomes and thus still reliant on sustainable farming practices to maintain their livelihoods.

Table 4.4. Analysis of determinant variables in the Logit model

Variable	β	S.E.	Sig.	e^{β}
Farmer characteristics				
AGE	-0.096	0.055	0.082[b]	0.908
GENDER	-1.906	1.076	0.076[b]	0.149
EDUCATION	-0.559	0.260	0.031[a]	0.572
TRUST	0.383	0.226	0.090[b]	1.466
Resource/economic characteristics				
INCOME	-0.017	0.009	0.048[a]	0.983
FARMSIZE	2.459	2.200	0.264	11.689
LABOR	0.399	0.295	0.176	1.490
FOODSECURITY	-0.193	0.083	0.020[a]	0.825
INFORMATION	0.574	0.556	0.302	1.775
Constant	4.692	3.096	0.130	109.122

Note: Cox & Snell R^2=0.299; Nagelkerke R^2=0.434; Overall percentage correct=81.8%
[a] Significant at 5%
[b] Significant at 10%

4.5 Conclusion

As the Logit model has shown, characteristics inherent to individual farmers can be valuable indicators of CA adoption. While age and gender cannot be changed, development practitioners can use this information to identify and understand the reasons why particular demographic groups may prefer to not adopt CA. On the other hand, factors such as education and trust can be fostered and investments can be made to enhance these characteristics and bridge the gaps in understanding between farmers and NGOs. Furthermore, education (formal or informal) can be targeted to better align with the skill needs and livelihood priorities of subsistence farmers. A better understanding of the dynamic relationship between factors such as income, food security, and interest in conservation agriculture can also provide insights into the drivers of farmer priorities and motivations. As we have shown, increased food security can allow farmers to invest in long-term sustainable farming practices, while increased off-farm income may hinder interest in farm management. This farmer-centric approach to understanding CA adoption highlights the barriers that may inhibit integration of new practices, while allowing for development practitioners to modify and adapt their programs to better incorporate farmer and community needs.

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Chapter 5: Conclusions

From the combined studies in this research, several barriers to adoption have been identified, along with areas where development approaches and farmer interactions can be improved to better meet both the needs of the local community and the environment. The application of a multi-dimensional nested research approach allowed for the use of appropriate methods to consider the social, cultural, and environmental dynamics at the various local levels. Within the community, it was shown that local environmental and socio-cultural contexts could influence the way that farming systems and introduced farming practices are perceived. Rural farmers adapt their understanding of the farm system based on their local environmental conditions and the farm conditions that they are most familiar with and thus view introduced agricultural practices through the lens of their own experience. In the villages, shared experiences and environments contribute to collective knowledge and may lead to similar perceptions and opinions of farming practices among community members. Additionally, for subsistence farmers, farm decisions are made with a short planning horizon in mind due to the dependence on the next harvest for food security. Therefore, it is crucial to prioritize food security needs and determine ways to mitigate crop production losses in the initial years of CA implementation. In contrast, researchers and NGO staff may view the farming system from a broader perspective and an understanding of the potential of alternate cultivation approaches. Yet, they may lack the local ecological knowledge and historical context that is ingrained in farmers as a result of lifelong on-farm exposure and experience. Identifying these gaps in perception, differences in group priorities, and ways of thinking are crucial for coming to a shared understanding of the farming system and cultivation practices. Moreover, by recognizing farmers' local expertise and identifying their needs and priorities, CA practices can be adapted to better suit local conditions and meet farmer and community needs at the local, community level.

The study of gender labor at the household level further revealed the complexities of agricultural labor and decision-making. An uneven distribution of both household and agricultural labor leaves women disproportionately overburdened, making the consideration of farming practices that may involve additional labor impractical and unsustainable. The lack of consideration for the vital reproductive household tasks often leaves women with a time-poverty, particularly during the cropping season. Nevertheless, in the on-farm trials, it was the women who took on the increased labor required from implementing CA practices. The agricultural tasks of land preparation, sowing, and harvesting were found to be the drivers of this increased labor from CA. Having identified the sources of increased labor demands, specific technologies can be developed to minimize the detrimental effects and improve overall implementation. It was further discovered that, for a majority of households, female heads of household have less than equal or no engagement in on-farm decision-making, as compared with their male counterparts. However, understanding these dynamics reinforces the need for development approaches that incorporate gender mainstreaming, are accessible to women, and promote women's engagement in community activities. Through increased engagement of those directly affected by CA adoption decisions, namely women, during the planning and implementation stages of CA projects, individuals can become more empowered to develop practical and sustainable solutions for farm management.

Analyzing individual farmer's characteristics to determine likelihood of adoption also revealed important barriers to CA implementation. It was established that farmers' age and gender both play a role in the likelihood of adoption. Further research into the underlying reasons why farmers in particular demographic groups may be more or less likely to adopt could provide insights into community socio-cultural structures and influences. Trust in NGOs was also a significant factor for adoption. This can encourage organizations to ensure that CA projects are aligned with farmer's goals and priorities to foster trust and facilitate communication. Off-farm income proved to be a barrier to adoption in this case, as it resulted in less adoption of CA and detracted from personal investments in maintaining the land. It was identified that opportunities for selling livestock, off-farm wage earning, and remittance all contributed to less interest in CA implementation. Similarly, higher education resulted in less likelihood of CA adoption. For subsistence farming communities, assessing informal skills training may be a more appropriate variable for adoption as compared with formal education, which can be difficult to access. While few households have access to consistent education and/or alternate income generating opportunities, it will nevertheless be important for future research to understand the dynamics between education, off-farm income, and agricultural livelihoods. In general, this type of information regarding farmer characteristics can be used not only to identify potential adopter groups, but also to identify and understand the limiting factors that may be inhibiting others from adopting CA.

Each of these methods for measuring conservation agriculture adoption provides a framework for assessing different aspects of subsistence livelihoods within the particular local context of a target community. By utilizing locally specific data and results, implementation of CA can be tailored to meet the needs of the community and individuals and enhance the potential for long-term conservation strategies. This research approach allows the perspective of understudied indigenous communities to be both understood and considered with regards to land use planning and policy development. As mentioned in Chapter 1, rapid changes to the natural and political environments calls for timely solutions to address the concerns of food security and land degradation. The traditional application of top-down development strategies has proven ineffective in producing long-term implementation of conservation agriculture practices, particularly in lesser-developed countries where such practices are most needed. The research approach presented here can be applied to similar smallholder farming contexts globally to understand the dynamic interplay between culture, gender, socio-economic status, and agro-ecological environment and the variations of these across different regions. Through promotion of collaborative management strategies for development practitioners working together with communities in the development of adapted and appropriate CA practices, this work can contribute to providing longer-term sustainable solutions for smallholder farmers.