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TECHNOLOGY USE IN AGRICULTURE AND OCCUPATIONAL MOBILITY OF FARM HOUSEHOLDS IN NEPAL: DEMOGRAPHIC AND SOCIOECONOMIC CORRELATES

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by

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ABSTRACT

Motivated by two major problems facing Nepal – the need to increase food production per unit of land and lessen population pressure in agriculture – the objectives of this research are twofold. The first is to examine the effects of household demographic, socioeconomic and neighborhood characteristics on the use of modern bio-chemical (chemical fertilizers and pesticides) and mechanical (tractors, pumpsets, and farm implements) inputs in agriculture. Despite the efforts by the government, the use of inputs in agriculture is very low. Studies suggest that no or low use of modern inputs is one of the major reasons for low and stagnant agricultural productivity in the country. This thesis seeks to provide new knowledge about the possible reasons behind the limited use of inputs in Nepalese agriculture. The second objective is to explore a recent phenomenon in Nepal, namely, the rapid change of occupation by farm households toward non-farm activities, in other words, exit from farming. I explore possible routes out of farming using household demographic, socioeconomic and neighborhood contextual characteristics as determinants of farm exit. No other study has examined these issues in Nepal.

To achieve these objectives, I analyze household- and neighborhood-level data collected from farm households in the western Chitwan Valley of Nepal. The evidence shows that presence of working-age family members is one of the important determinants limiting adoption of labor-saving technologies in farming. Moreover, although presence of both working-age men and women family members matter, the presence of women is more important than men in technology adoption decisions. Socioeconomic characteristics such as land ownership, education, exposure to communication media, and ethnicity also were

important in the adoption of these technologies. Further, the availability of services such as banks, cooperatives, and bus service in the community were not associated with the adoption of modern inputs. The findings question the relevance of the government's policy to increase adequate and timely distribution of modern inputs, at least in this setting of Chitwan Valley.

On occupational transition, the findings revealed that the availability of working-age individuals in a household particularly children, the access to cultivated land, and the keeping of livestock hindered farm exit decisions. The access to community services, the effect of which was mediated by the proportion of non-farm households in the community, was found to be an important route out of farming, perhaps suggesting that greater off-farm employment opportunities were influential in households' decisions to leave farming.

In conclusion, this study provides evidence that in addition to other socioeconomic and neighborhood characteristics, the presence of family labor is one of the obstacles to adoption of modern inputs. This could be an important explanation for the no or low use of modern inputs, and subsequently, the persistently low and stagnant productivity of Nepalese agriculture. This study also suggests that the development of community services particularly suitable for small holder farmers with no livestock may facilitate farm exit, which could relieve population pressure in agriculture. Since the primary focus of the Nepalese government is to increase food production per unit of land and to divert the farm population toward off-farm sectors, the policy implications and suggested avenues for further research stemming from this research are especially salient.

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CHAPTER 1

INTRODUCTION

"Nepal faces two of the major problems of development – the need to increase food agricultural productivity and the need to relieve population pressure on the land."

-Ashby and Pachico (1987:195)

1.1. Objectives

In Nepal, the household economy is overwhelmingly agriculturally based. Over 80 percent of the economically active population is primarily engaged in agriculture. The population is also growing very fast with an annual growth rate of 2.27 percent during 1991-2001 (CBS 2002). As a result of high population growth, the pressure of population per unit of land is increasing over time. For instance, the population density increased from 102 persons per square kilometer in 1981 to 125 persons per square kilometer in 1991 (CBS 1999). Currently, it is 158 persons per square kilometer in 2001 (CBS 2002). This increased pressure on the land has reduced the per capita land availability. The gross cropped area per agricultural worker has decreased from 0.47 hectares in 1971 to 0.43 hectares by 1991 (Silwal 1995).

Growth of food production, however, has not matched the growth of population. Increasing pressure of population pressure on the land, therefore, has further led to the extension of marginal land under cultivation, thus resulting in a decrease in agricultural productivity (Chitrakar 1990). Moreover, the use of technological inputs such as fertilizers, high yielding variety seeds, irrigation, pesticides, machines and other improved farm implements, that might otherwise increase food production, is very low. This has resulted in a slow growth of food production in Nepal (APP 1995; Chitrakar 1990). This cycle, an increase in marginal land under cultivation due to increase in population pressure, which further results in low food production per unit of land has been termed the low productivity trap (UN 1997).

An increase in food production to feed the growing population is a priority of the nation. It is recognized that it is possible to avoid the low productivity trap and increase agricultural productivity by bringing more land under irrigation, using high-yielding varieties of seeds and chemical fertilizers (UN 1997; APP 1995). Therefore, the government has particularly focused on the provision of various inputs such as high-yielding variety seeds, chemical fertilizers, pesticides, irrigation, and mechanization to encourage their use. The government recognizes that “unless there is an extensive use of the technology to raise the productivity per unit and be competitive in the production aspect, agricultural development cannot be accelerated” (NPC 2003a). The Agricultural Perspective Plan (APP) has been in operation in the country since 1995 with the goal of agricultural development. Despite this, the use of technological inputs is low and growth of food production is also low.

In Nepal, where family labor is the major source of agricultural labor, the availability of family labor along with other socioeconomic factors might be important obstacles to the use of labor-saving agricultural technologies. It necessitates a study of the factors affecting the use of modern inputs in agriculture at the household-level. Accordingly, the first objective of this study is to examine the effect of labor availability in a household along with other socioeconomic and neighborhood contextual factors on the use of agricultural inputs in Nepal.

The shift of occupation from farm to non-farm activities by individuals and even all the members of a farm family has been a recent phenomenon. This shift serves to lessen population pressure on agricultural land. Therefore, the second primary concern is the need to understand the various factors that encourage or discourage occupational mobility of farm households in the agricultural setting of Nepal. Emphasis is placed on household demographic and other variables, as well as neighborhood characteristics to better understand exits from agriculture.

1.2. Family Labor Availability and Technology Use in Agriculture

The agriculture sector remains the major source of income and employment for the majority of people in Nepal. Over 80 percent of the economically active people are engaged in this sector today (Ministry of Health [Nepal], New ERA, and ORC Macro 2002). Similarly, in recent years (1999/2000), over 40 percent of national income has come from agriculture, down from over 49 percent in 1990/1991 (ANZDEC Ltd. 2002). Realizing the importance of agriculture in generating income and employment, the Nepalese government has emphasized development of this sector from the very beginning of its planned development history (NPC 1998, 2003a; Pant and Jain 1969). The government accorded top priority to the agriculture sector after the fifth national development plan (1975-1980). Farmers were encouraged to use modern inputs such as high-yielding varieties of seeds, fertilizers, irrigation, tractors, pumpsets, farm implements, and pesticides. Subsidies were provided for various inputs. Farm credit was made available to farmers at subsidized rates. Extension services for the dissemination of information and markets for the distribution of inputs and outputs were emphasized.

Despite various efforts, crop productivity or yield, also called the production per unit of land, has remained almost stagnant or in some years declined during the last three decades. The increase in food production is mainly due to land expansion rather than the use of technology (APP 1995; Ashby and Pachico 1987; Chitrakar 1990). Karan and Ishii (1996) reported that during the 1961/62 and 1980/81 periods, total food production increased by 1.10 percent per year, while productivity declined by 0.58 percent per year. It is further reported that the increase in production through the expansion of cultivated land has already reached its limit as the supply of additional land suitable for agriculture is almost exhausted (Ashby and Pachio 1987). Therefore, modernization of agriculture by providing farmers with new technologies is believed to be an alternative to minimize the growing imbalance between resources and population (APP 1995).

With this view in mind, the Nepalese government formulated and implemented a twenty-year agriculture development plan called the Agricultural Perspective Plan (APP) in 1995 to meet the food demand of an ever increasing population and raise their socioeconomic base (APP 1995). The main focus of the APP is to develop the agriculture sector by encouraging farmers to use green revolution technologies such as irrigation, fertilizers, and high-yielding varieties of plant seeds. The plan expects that development of the agriculture sector will generate large multiplier effects throughout other sectors of the economy. For example, the income earned from agriculture can be invested for the growth of other sectors such as trade and services, transport, rural industry, and construction to name a few. Such multiplier effects would generate employment and thus, help increase the income of the poor.

The APP recognizes that the low level of agricultural yield is due to the low use of technology in agriculture. For example, to date only about 18 percent of the arable land has been provided with year-round irrigation (APP 1995; NPC 2003a). The APP (1995) further reports about 2.2 million hectares of land including forest land (1.8 million hectares of land excluding forest land) can be potentially irrigated. By ecological regions, about 1.8 million hectares (77 percent) of land in the Terai, 0.4 million hectares (20 percent) in the Hills and 0.06 million hectares (3 percent) in the Mountain regions is potentially irrigable (including forest land). However, only 0.4 million hectares of land receives year-round irrigation by 1993. Of the total irrigated land, 0.3 million hectares (69 percent) is in the Terai, 0.1 million hectares (27 percent) in the Hills, and about 0.02 million hectares (5 percent) is in the Mountains. Similarly, the average use of chemical fertilizer is very low, at 31 kg/hectare, one of the lowest among the neighboring countries in 1990 (APP 1995). Moreover, the number of fertilizer users is not very high. The Central Bureau of Statistics in 1993 reported that only about half of the paddy and wheat growers used fertilizers in 1991/92 (CBS 1993), and the users of improved varieties of seeds and pesticides remain low (Bastola 1998). Therefore, the APP (1995) strategy considers accelerated technological change, which is supposed to increase the demand for the production of high-value commodities in agriculture as well as in nonagricultural sector, as the means to increase agricultural production and incomes in the country. The technological change in agriculture, which involves the increase in the use of modern inputs, will accelerate agricultural growth through its large multiplier effects on the growth of employment in both agriculture and nonagricultural sector.

The Chitwan district, where this research is focused, is considered to be one of the most accessible agricultural districts in terms of market, transportation, and communication facilities in the country. The 1996 Population and Environment Study (PopEnv) conducted in the Chitwan Valley and the data source for this research reported that some households were not using these inputs. For instance, although a large proportion of farming households (82 percent) used chemical fertilizers, still about 18 percent of households were not using them at all. On the other hand, only 23 percent of the farming households were using pesticides despite reporting disease and insect problems. Presumably, the situation should be much worse in other districts of Nepal as compared to the Chitwan Valley. This is primarily because Chitwan district, particularly the Chitwan Valley, is one of the most accessible areas in the country in terms of development networks such as transportation and communication.

Inadequate and untimely supply of modern inputs materials is considered to be the major impediment to their use (APP 1995; NPC 1998, 2003a; Pant and Jain 1969). Considering this, every planning document including the APP has emphasized ensuring a timely and adequate supply of these materials, assuming that this would simply translate into their adoption by farm households. While this logic is compelling, I argue that non-use of these inputs whether or not distribution is a problem may be associated with other factors such as the availability of household labor. This is because family labor is the major source of farm labor in Nepal; and green revolution technologies such as tractor use, fertilizers, pesticides, and high yielding varieties are considered to be labor-saving techniques (Boserup 1965). If labor is already available in a family to carry out various farm activities, I expect that the household might be reluctant to use such labor-saving modern inputs. The role of human resources, particularly the availability of family labor on agricultural modernization, however, has not been emphasized by the APP (ANZDEC Ltd. 2000), as well as the current agricultural development plans of Nepal.

Available empirical studies have primarily focused on economic factors such as farm size (for example, Feder and O'Mara 1981; Rauniyar and Goode 1996) and cultural factors such as ethnicity and village factors (for example, Godoy, Franks and Claudio 1998). In the Nepalese context, Pant and Jain (1969) reported surplus labor as one of the obstacles to agricultural development arguing that per capita income remains low due to the availability of surplus labor and therefore, there are almost no savings for further agricultural improvement. In recent years, studies have focused on the negative effect of population pressure on agricultural production (Chitrakar 1990; Karan and Ishii 1995). It is widely reported that high growth of population in agriculture has encouraged farmers to increase marginal land under cultivation. This situation has resulted in a lower food production per unit of land in the country. It has been realized that the large pool of agricultural labor force can be an important asset for the development of other sectors of the economy such as industries and tourism.

On modern inputs use, studies of fertilizer use have focused on macro-economic factors such as demand and supply aspects of fertilizer (ESCAP/FAO/UNIDO 1997a), fertilizer policy issues (Joshi 1998; Tamrakar 1998) and fertilizer trade liberalization issues (Basnyat 1999; Ministry of Agriculture and Cooperative 2000). These studies have primarily focused on the macro-level issues of fertilizer acquisition, pricing mechanisms, and the distribution systems in the country. Studies of factors affecting modern inputs use at the micro-level are virtually absent, however. In 2003, a study conducted by the Ministry of Agriculture and Cooperatives focused on the household-level factors affecting the use of fertilizers (Ministry of Agriculture and Cooperatives 2003). This study examined factors such as the price of fertilizer, prices of major agricultural outputs, wealth of household, size of cultivated land, and irrigation as some of the important determinants of fertilizer use.

Regarding agricultural mechanization, research has examined the impact of mechanization on crop production, employment and income (Pudasaini 1979) and the status of the use of mechanization in Nepalese agriculture (Salokhe and Ramalingham 1998; Shrestha 1998). There is a paucity of studies that examine the effect of household-level demographic factors on the use of various inputs in crop production, however. With this background in mind, the first research question of this study is: To what extent do household-level demographic factors, particularly the availability of family labor influence the use of technologies in crop production, net of socioeconomic and neighborhood contextual factors?

1.3. Occupational Mobility of Farm Households (Farm Exit)

The second objective of this study is to explore occupational mobility of farm households (farm exit). Although agriculture is the major occupation of a majority of people, shift of occupation by individuals living in farm households to non-farm activities has been much more apparent in recent years. As a result, the proportion of people dependent on agriculture has been declining over time at the national level. For instance, up until the 1970s, over 94 percent of the economically active population was engaged in farming and related activities. This proportion has declined to about 81 percent in 1991 (Sharma and Kayastha 1998). Recently, the 2001 Demographic and Health Survey (DHS) for Nepal reported about 80 percent of the economically active population still engaged in agriculture (Ministry of Health [Nepal], New ERA, and ORC Macro 2002).

Within households, it is often not only one or two individuals but all members who have changed from farming to non-farming occupations, termed a household occupation shift (farm exit) in this study. The shift in occupation might be due to the fact that the farm sector is not providing gainful employment, and the income generated from the agriculture sector is not enough to meet the needs of household members. It is also not clear if this shift is due to adoption or non-adoption of modern agricultural inputs.

The study area of western Chitwan Valley is not an exception to this process. The shift in occupation by individuals as well as households from farming to non-farming activities is taking place rapidly. For example, in the 1996 Population and Environment Study, of the total 1,583 households surveyed, over 80 percent (n = 1,269) of households reported to be engaged in farming activities. Among these 1,269 farming households, a total of 1,216 farming households were resurveyed in 2001. Others are missing information due to various reasons such as out-migration, household merging, and missing household address. Among them, 92.5 percent (n = 1,125) of households continued farming, whereas 7.5 percent (n = 91) of households had left farming by 2001. While this rate of attrition might not seem especially rapid, that it occurred in only five years makes it significant.

Despite these observations, the demographic and socioeconomic characteristics of households and the neighborhood contextual factors that contribute to such a shift in a household's occupation remain unclear. Although literature on factors affecting farm exit exists particularly focusing on developed countries (for example, Goetz and Debertin 2001; Kimhi and Bollman 1999; Peitola, Vare and Lansink 2002; Glauben, Tietje and Weiss 2003), such studies are virtually absent for Nepal.

The national population census records occupation of individuals such as agricultural, professional and technical, services, administrative and others (CBS 1995). It reports the proportion of people by occupation categories, and occupation by sex, education and residence. Comparative data are also provided on changes in the occupational distribution between censuses. However, the Central Bureau of Statistics (CBS), Nepal, does not report who either continues in or changes their occupations, nor why, which requires longitudinal information about the same individual or household. Accordingly, the second fundamental research question addressed in this study is: What demographic, socioeconomic, and neighborhood contextual factors influence the shift of household occupations from farming to non-farming activities (farm exit)?

1.4. Significance of the Study

This study has important theoretical and practical significance in agricultural settings such as Nepal. First, as most studies have basically focused on economic factors, this study examines household-level demographic factors as potentially important contributors to technological adoption in agriculture. Moreover, this study examines many other social, economic, and neighborhood variables that affect input use in agriculture. By identifying the links between various factors such as family labor availability, their sex composition, age and sex of the head of the household, household socioeconomic background, and neighborhood context on technological adoption, the findings serve as a basis for better informed and finely tuned policy prescriptions for agricultural development in Nepal. As noted, agriculture development policies have focused on the provision and distribution of inputs and services, stressing inadequate supply and high prices as barriers to their use, without focusing on why farm households do not use various agricultural inputs given their availability. Alternatively, this study focuses on various factors that affect the adoption of agricultural inputs at the household-level, which is another potentially important contribution.

Second, the findings of this study might be of importance in agricultural settings of other countries of South Asia (for example, Bangladesh and India) and other regions where population is growing rapidly and food production is barely matching the needs of fast-growing populations. Moreover, the findings might be useful in countries where the uses of inputs and food production have not increased despite government efforts to increase food production by encouraging the use of agricultural inputs.

Third, this study also explores factors contributing to occupational shifts of households from farming to non-farming activities. It is obvious that in the past the occupation of a majority of people in many countries, which are now developed, was farming. For example, in the USA, the proportion of agricultural labor force in 1820 was 71.8 percent, which dropped down to 7.1 percent by 1960 (Moore 1966). In the former Soviet Union, the proportion of the labor force in agriculture was over 85 percent in 1925, decreasing to about 48 percent by 1959. The proportion involved in agriculture in the United Kingdom was 35.9 percent in 1801 that decreased to 5 percent in 1951. In many developing countries the proportion of agricultural labor force is still very high, but is declining over time. It is important to understand the factors that influence exits from agriculture, the study of which requires longitudinal information on the same individuals or households.

This study contributes by exploring some of the household demographic, socioeconomic and neighborhood contexts that influence households' occupational transition in an agricultural setting. By analyzing panel data on households at two points in time, 1996 and 2001, the study affords the unique opportunity to understand the demographic and socioeconomic dynamics of farm exit at the household level. While a limitation of this study is that the data do not provide information about which non-farm sector these exiting farming households wind up in, the data do allow for a first-time glimpse into this important phenomenon that is on the rise in Nepal today.

1.5. Organization of the Dissertation

The study is organized into seven chapters. Chapter 1 has focused on the objectives of the study, the statement of the problems, the research questions and the significance of the study. Chapter 2 describes the research setting, the western Chitwan Valley of Nepal. This chapter, first, focuses on various characteristics such as the geography, economy, and the infrastructure of Nepal, in general, and then on the western Chitwan Valley, in particular. Chapter 3 describes various theoretical approaches related to technology use in agriculture and occupational mobility of farm households. Empirical evidence related to these issues is also discussed. Finally, I present the conceptual framework and the study hypothesis at the end of this chapter. Chapter 4 describes the research methods employed. I describe various data sources used in this study, the conceptual and operational definitions of variables and the methods of data analysis. Chapters 5 and 6 present the results of the statistical analysis. Chapter 5 describes the results related to technology use in agriculture. Chapter 6 explores various factors contributing to occupational mobility of farm households and describes their effects. Finally, the results are summarized and discussed in Chapter 7.

CHAPTER 2

THE STUDY SETTING

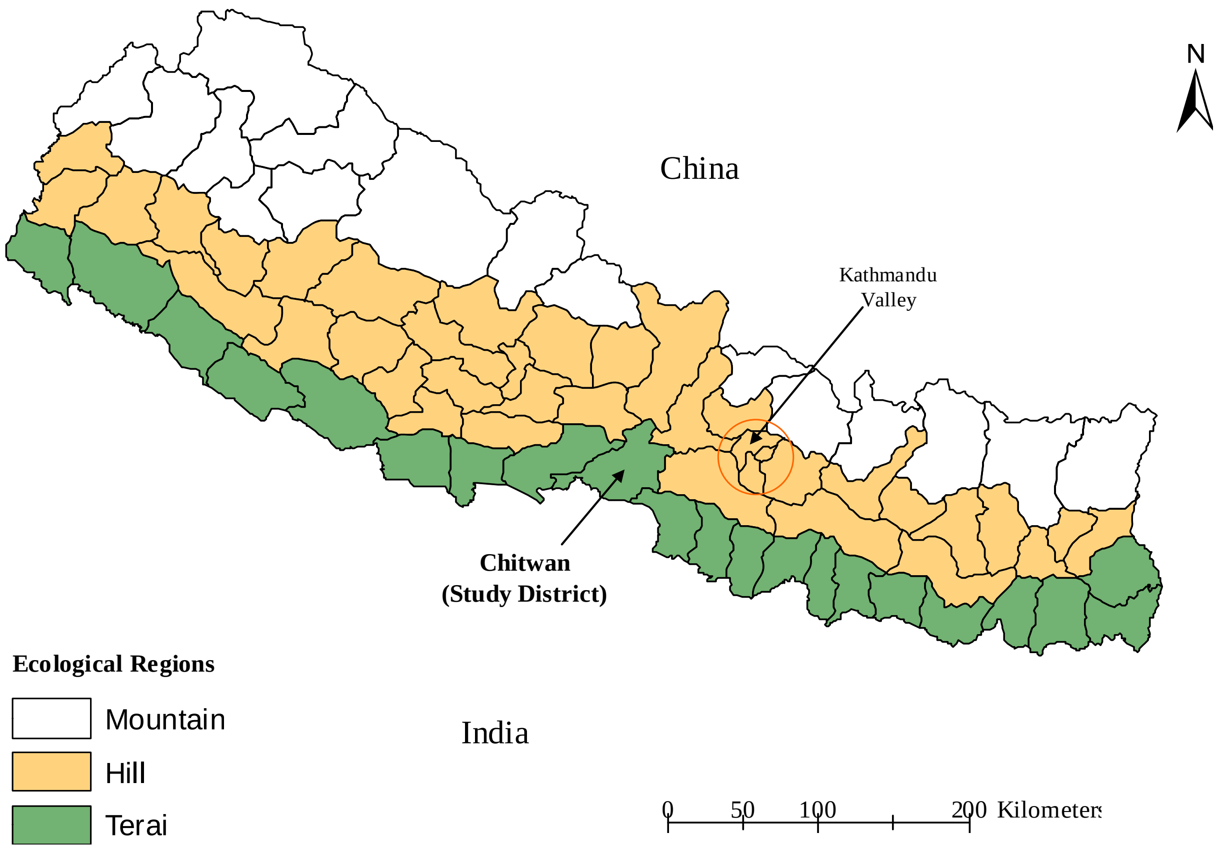
The western Chitwan Valley situated in the southern plain of central Nepal is the setting for this study. The policy environment at the national level affects the situation at the local level. Therefore, first, I provide a brief picture of the geography, economy, and socio-cultural perspective of Nepal. Then, I focus on the western Chitwan Valley.

2.1. Nepal – The Geography

Nepal is a land locked Himalayan country situated between two world giants, India to the south and China to the north (Fig. 2.1). It has a total area of 147,181 square kilometers (56,813 sq. miles) making it slightly larger than Iowa (56,276 sq. miles). The geographic location of the country is between 26 degrees to 30 degrees north latitude and 80 degrees to 88 degrees east longitude. Ecologically, the country is divided into three regions – the Mountain, the Hill and the Terai. For administrative purposes, the country is divided into five developmental regions, 14 zones, and 75 districts.

The Mountain region is the northern most part of the country. The altitude of this region varies from 4,877 meters to 8,848 meters above the sea level and includes the highest point in the world. In total, 16 districts fall in this region. This region covers over 35 percent of the total land; however, only 2 percent of it is suitable for agricultural purposes. The Hill region is located between 610 meters and 4,877 meters above the sea level. There are 39 districts in this region. This region consists of about 42 percent of the

Fig. 2.1. Map of Nepal Showing Ecological Regions and the Study District



total land area with only one-tenth of it being suitable for cultivation. The Terai region is the southern most part of the country consisting of 20 districts. It occupies about 23 percent of the land. About 40 percent of the total land in this region is suitable for cultivation purposes. This region lies in the highly productive Indo-Gangetic plain, and is commonly known as the “granary” of the country.

2.2. Population

The 2001 national census recorded a total population of over 23 million in Nepal (CBS 2002). The population is estimated to be 26 million by mid-2006 (PRB 2006). By ecological regions, about 7 percent of the population resides in the Mountains, 44 percent in the Hills and 49 percent in the Terai region. Over 86 percent of the population still lives in the rural area of the country.

The population is rapidly growing. A population growth rate of about 1.64 percent per year recorded in 1961 reached a peak of about 2.66 percent per year during the 1971-1981 period. The 1991 census recorded a growth rate of 2.1 percent per year during 1981-1991. However, the recent 2001 census reported a growth rate of 2.27 percent per year during 1991-2001. Of course, the population density is also, therefore, increasing rapidly. In 1981, it was 102 persons per square kilometer, which increased to 158 persons per square kilometer by 2001. As described, that the Terai region has half the population but less than a quarter of Nepal’s territory, makes population density and land pressure much more salient there.

Obviously, ever increasing population and a scarcity of cultivable land has increased the pressure on existing forest land thus increasing deforestation in the country

(Karan and Ishii 1995). Similarly, Shrestha (1990) also indicated that Nepal has already reached a maximum threshold of land expansion for agricultural purposes. This has resulted in the expansion of marginal lands for crop cultivation to increase food production for ever increasing population. The available carrying capacity estimate for Nepal also suggests that the limit of population to be supported by the land resource of the country has already exceeded (Beinroth, Eswaran and Reich 2001).[1]

Regarding population, despite the onset of the fertility transition during the 1970s, Nepal still remains a high fertility country (Table 2.1) in the South Asia region. The 2006 World Population Data Sheet of the Population Reference Bureau (2006) reported a total fertility rate (TFR) of 3.7 in 2006 in Nepal, which is followed by Bhutan (4.7) and Pakistan (4.8), the high fertility countries in the region. Only 39 percent of the currently married non-pregnant women of age between 15-49 years used any modern contraceptives. Despite a sizable decline in infant mortality in other parts of the developing world, it still remains high in Nepal (64 deaths per 1,000 live births in 2005), second highest in the region after Pakistan (85 deaths per 1,000 live births in 2005).

Regarding high population growth as a key obstacle to national development, the Nepalese government announced its first population policy during the third national development plan (1965-1970). The focus of the population policy was to bring down the birth rate by providing family planning services. The subsequent plans also adopted policies geared toward reducing the high population growth. The Ministry of Population and Environment advanced a twenty-year population policy during the Ninth Plan (1997-2002) with a goal to bring down the fertility rate to a replacement level (2.1 children)

[1] Estimates suggest that Nepal's land resource would support 5.8 million, 11.7 million, and 22.8 million people under low, medium, and high levels of technology inputs level, respectively.

within 20 years. This plan also emphasized the provision of family planning and maternal-child health services. The current Tenth Plan (2003-2007) has also continued this policy and has set a target to reduce the fertility rate to the replacement level by the year 2015 (NPC 2003a). With less than a decade to go, this seems unlikely.

Table 2.1. Total Fertility Rates, Infant Mortality Rates and Contraceptive Prevalence in Nepal (1971-2005)

Year	Estimated Total Fertility Rate (TFR) per Woman[1]	Estimated Infant Mortality Rate per 1000[2]	Contraceptive Prevalence (Percent)[1]
1971	6.3	172	-
1974/75	6.3	133	-
1976	6.4	134	2.9
1977/78	6.2	104	-
1981	6.3	117	7.6
1986	6.0	107	15.1
1991	5.4	97	21.8
1995	5.2	79 (1994)	28.5 (1996)
2005[3]	3.7	64	39.0 (35)

Sources:
[1] UN 1997a
[2] Sharma and Kayastha 1998
[3] PRB 2006; (all methods 39 percent and modern methods 35 percent)

2.3. Economy

Economically, the country is largely agriculturally based. However, only one-fifth (2.32 million hectares in 1984) of the total land is under cultivation. Yet, the agriculture sector provides employment to a large majority of the economically active population. The contribution of this sector to the national economy is also high, 40 percent of the Gross Domestic Product (GDP) in 1997/1998. Other sectors of the economy are small cottage industries, tourism, manufacturing, and garment industries.

Poverty is a common phenomenon in Nepal, which is recognized as among the poorest countries in the world. Although the government reported over 38 percent of the people below the poverty line (NPC 2003b), the figure varies and is thought to be much higher. For example, the United Nations Development Program Country Assessment for Nepal (2000) reported about half the people to be income-poor. The per capita income is low, 210 US$ (NESAC 1998). In 2000, 51 percent of the population was literate, average life expectancy was 59.5 years, and about 20 percent of the people had no access to potable drinking water (NPC 2003a).

Although land is the basic means of livelihood to a large majority of people, the per capita agricultural land availability is very low and is declining over time (Chitrakar 1990; Shrestha 1990; Karan and Ishii 1996; Shrestha 1966). In 1961, the per capita agricultural land availability was recorded to be 0.190 hectares (0.470 acres; 1 acre = 0.405 hectares) per person (Shrestha 1966). It decreased to 0.155 hectares (0.383 acres) per person in 1984. The lowest amount was reported in the Mountains (0.099 hectares) followed by the Hills (0.105 hectares) and the Terai (0.219 hectares) (Chitrakar 1990). It further decreased to 0.140 hectare (0.346 acres) per person by 1998 (Bastola 1998).

Fragmentation of land parcels is also high (APP 1995). In 2001/2002, the average number of parcels per holding is reported to be 3.3 (CBS 2004). The average number of parcels is positively associated with the size of holding with 1.3 parcels for less than 0.1 hectare of land to 6.5 parcels for holdings of size 10 hectares or more. In 1991/1992, on the average, about 4.0 parcels per household were reported and one hectare of land was reported to be scattered into 4.2 different places. The number of parcels per hectare of cultivated land is generally higher in the Mountain (6.8) and Hills (5.1) and lower in the

Terai region (3.1). The average number of parcels for the Chitwan district (study district) was reported to be 1.7. The main reason behind land fragmentation is the sub-division of land resulting from household fission, where parental land is sub-divided among heirs, particularly sons. On top of this, the distribution of land is highly skewed. While almost half of farm families own less than 0.5 hectare, 16 percent of the families own about 63 percent of the land (Ministry of Population and Environment 2002a). This scenario also holds true for the Chitwan Valley Family Study (CVFS) area. While about 45 percent households had access to less than a hectare of cultivated land, over 71 percent of them had access to less than a hectare of it (data not shown).

The open border system with India has a large impact on the economic policy-making environment of the country. Although there is restriction imposed on the free flow of commodities through the custom offices, because of the open border system there is an easy inflow and outflow of commodities. Both agricultural products as well as inputs such as fertilizers are exchanged by the traders and farmers.

2.4. Agriculture

The agriculture sector is traditional in nature and basically subsistence oriented. The household economy is crops and livestock integrated and these two components are highly interdependent (ADB 1990; Bhandari et al. 1996; Gurung 1987; Singh and Shrestha 1990; Shrestha et al. 1990; Yadav 1990). In general, households cultivate some land to produce foodgrains and raise livestock for animal protein (milk, meat and eggs), draft power and manure. The households provide labor for crops and livestock production; crop production provides food for both humans and animals; and animals, in turn, provide protein for humans and manure and draft power for agriculture. Among foodgrains, households primarily produce cereal crops such as paddy, maize, wheat, millet, and barley. In 1991/1992, cereals occupied over 80 percent of the total cropped area (Bastola 1998). Paddy rice occupies over half of the total area under cereals.

Realizing the importance of agriculture in the household as well as in the national economy, the government focused its priority to develop this sector since the very first national economic development plan (1956-1961). In order to show further commitment, the government accorded top priority to this sector in the fifth development plan (1975-1980). A regional development concept was implemented. The Terai region was emphasized for foodgrain and cash crop production and the Hill and Mountain regions were designated for fruits, vegetables and livestock production. To put more emphasis on agriculture, the government implemented a twenty-year Agricultural Perspective Plan (APP). The APP's main goal is to increase production and incomes of households by encouraging farmers to use green revolution technologies such as irrigation, fertilizers, and high-yielding varieties (HYVs) of plant seeds (APP 1995).

Controversies exist worldwide about the benefits of green revolution technologies, however. Some (for example, Cleaver 1972; Griffin 1974; Jacoby 1972) believe that the use of green revolution technologies largely benefited larger farmers since they have control over large amounts of land resources and can afford to use various technologies. Jacoby (1972) believes that the green revolution has not resulted in developments particularly in South Asia, but rather has shaken the economic foundation of agricultural population in these countries. In his view, the green revolution has benefited large land owners by increasing the productivity and returns from the land due to the use of new technology. Tenants meanwhile, an important feature of the South Asian agriculture, have been ignored and do not benefit from the green revolution. In short, it is argued that the rural poor do not receive a fair share of the benefits generated from the green revolution. From an employment perspective, Cleaver (1972) and Griffin (1974) also argued that most of these technologies such as the mechanization of farms are labor-saving and replace agricultural labor further adding to the burden of existing unemployment. From an environmental perspective, use of chemical fertilizers and pesticides may jeopardize the environment by leaching out chemicals into bodies of water, poisoning food, and damaging insects and pests (Pimentel and Pimentel 1991).

Others advocate for the benefits of the green revolution (for example, Hazel and Ramaswamy 1991; Lipton 1989; Mellor 1976; Sen 1975). In Sen's (1975) view, the arguments made by the opponents of green revolution are 'misconceptions'; whereas Hazel and Ramaswamy (1991) point out that the benefits of the green revolution have been overlooked. For example, food production has increased after adopting these techniques, food prices have declined in some countries and the poor have benefited from lower food prices. Hazel and Ramaswamy (1991:3) further argue that "little or no attention was given to indirect growth linkages of the green revolution with the rural non-farm economy and the resulting impact on the income of the poor." Moreover, Mellor (1976) believes that as a result of labor-intensive linkages with the rural non-farm economy, the agricultural growth emphasized on small- and medium-sized farms will generate rapid, equitable, and geographically dispersed growth. The Agricultural Perspective Plan (APP) initiated in Nepal was designed and implemented with the help of John Mellor Associates, Inc., Washington D.C. The plan is inspired by Mellor's belief that the rural poor benefit from income-earning opportunities that are developed in the local non-farm economy due to the large multiplier effects of agricultural growth in other sectors of the economy, ultimately reducing poverty in Nepal (APP 1995).

As a result of the past efforts, farmers in Nepal are gradually shifting farming practices from traditional organic to modern chemical farming (Ministry of Population and Environment (MoPE) 2002). The government, for the first time, introduced chemical or mineral fertilizers in 1952. The ministry reports that in 1955 the volume of fertilizer consumption was only 10 tons. The volume of fertilizer consumption increased to over 1,500 tons in 1965. By 1994/95, total sale of mineral fertilizers increased to over 185,797 tons. The volume of fertilizer distribution after 1995 is not clear as the private sector was involved to procure and distribute fertilizer.

Despite these increases, per hectare use of chemical fertilizer is still very low by South Asian standards, an average of 31 kg per hectare per year in 1991 (APP 1995), when the use of chemical fertilizers in neighboring countries such as in Bangladesh was 101 kg/ha followed by Pakistan, 91 kg/ha and India, 71 kg/ha. Therefore, under the Agricultural Perspective Plan, the target has been set to increase fertilizer use to about 150 kg per hectare per year by the year 2015. After the implementation of the APP, there has been a high growth of fertilizer use by households in the first four years of the Ninth development plan (1997-2002) (ANZDEC 2002). However, per unit use is still below South Asian standards (58 kg/ha in 2000/01). Moreover, despite the report of heavy crop loss due to insects, diseases, and weeds (Chitrakar 1990), the uses of pesticides and herbicides is very low (Bastola 1998). For example, only 13.2 percent of paddy, 5.4

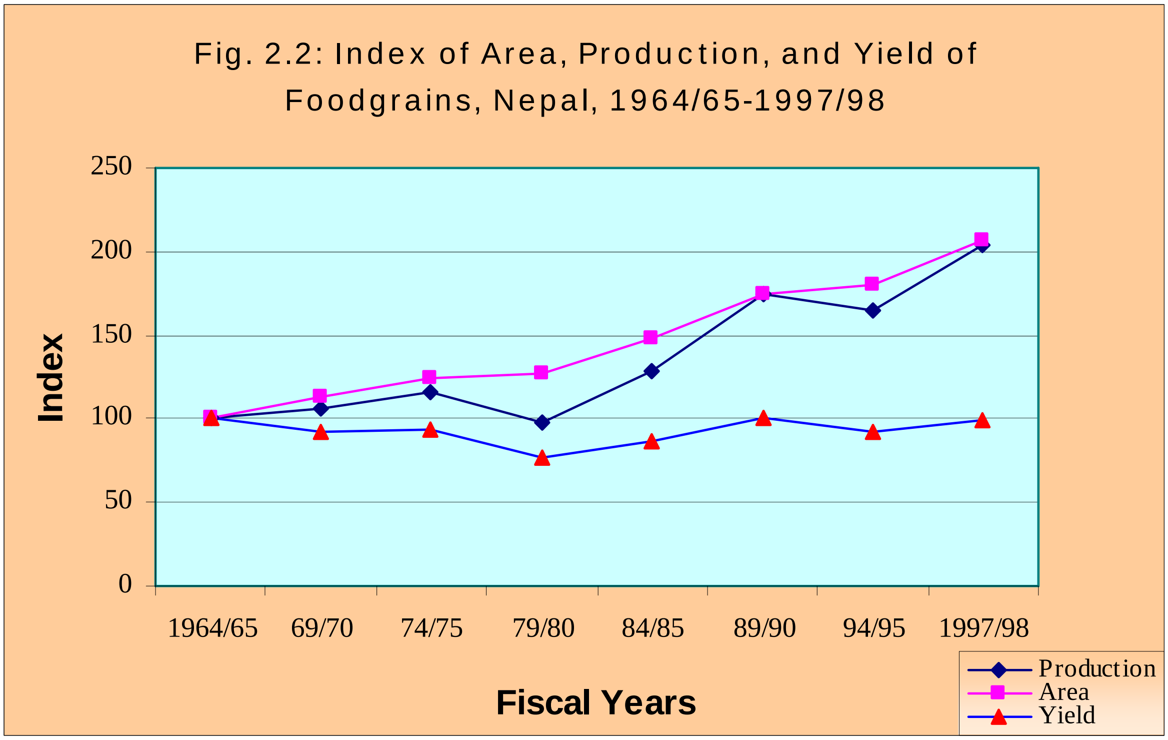
percent of wheat, and 3 percent of maize growers were reported to be using pesticides in 1991/92.

Consumption of improved seeds is also increasing over time. According to the 1997 report of the Ministry of Finance, the volume of high yield variety (HYV) seeds increased from 1,934 metric tons in 1974/75 to 3,343 metric tons in 1997/98 (Bastola 1998). However, the use of improved seeds at the farm level is still low. Bastola (1998) reported that only about one-fourth of wheat growers and over one-tenth of the paddy growers used improved seeds in 1998.

Irrigation is another important aspect of agricultural modernization. Although Nepal is rich in fresh water resources, the country's agriculture has very limited access to irrigation water. A large part of arable land still depends on monsoon rains. Further, the distribution of rainfall varies by topographic regions and seasons. For example, although the annual average rainfall is over 1,500 mm, the volume of rainfall ranges from 250 mm in the northern Mountainous region to about 5,000 mm in the southern Terai plain (Silwal 1995). About 80 percent of the total rainfall occurs during June to September. Nevertheless, the rainfall is erratic and there is no certainty of when the monsoon begins and ends every year. Therefore, the year-round provision of well-controlled water sources (i.e., a regular source of irrigation water) is a must for good crop harvests.

The government has focused its investment priority on irrigation from the very beginning of the planned development history. However, only 18 percent of the arable land is provided with well-controlled year round water supplies thus far (APP 1995). The development of irrigation has been concentrated in the Terai region. For instance, the APP reported that in 1993, 68 percent of the actually commanded area under irrigation was in the Terai, followed by 27 percent in the Hills and only 5 percent in the Mountains. The recent plans also focus on the development of ground water and surface water irrigation and provision of shallow and deep tube-wells to increase the availability of irrigation, particularly in the Terai region of the country.

Mechanization of agriculture, such as the use of tractors, pumpsets, and other improved farm implements like threshers, improved ploughs (mould board plough), and sprayers increases yields in agriculture through better soil preparation, better water, pest and fertilizer management, reduced crop loss and timeliness (Pudasaini 1979; Salokhe and Ramalingham 1998). Although the history of agricultural mechanization dates back to the 1960s, when the government first imported tractors and pumpsets and made them available to farmers, Nepalese agriculture still depends heavily on human and animal power. Salokhe and Ramalingham (1998) reported that human and animal labor, respectively constituted 30 percent and 48 percent of the total farm power. The rest is contributed by mechanical power. They pointed out that only 0.625 kilowatts of farm power were available per hectare of cultivated land in 1997 and opined that "[t]his farm power availability is extremely low for productivity increases in agricultural sector" (Salokhe and Ramalingham 1998:10). The Terai plain is relatively accessible due to relatively well developed transportation infrastructure and is suitable for mechanization. Therefore, the use of tractors, pumpsets, and other improved farm implements is increasing over time in this region. Use of machines and farm implements, particularly in the Hills and the Mountains, is hindered by geographical difficulties and lack of transportation networks.



Source: CBS 1999; Chitrakar 1990.

On the food production side, the recent trends show an increase in total food production, however, the production per unit of land also called yield or productivity is not encouraging (Fig. 2.2). The increase in overall food production is reported to be mainly due to an increase in the total land under cultivation (Chitrakar 1990; Karan and Ishii 1996; UN 1997). Chitrakar (1990) reported that the production of cereals (food grains) increased at an average of 2.96 per cent per annum, below the targets of the periodic plans of 3-4 percent per year during the last 25 years, and that the area under cultivation also increased by the same rate of 2.96 percent per year. However, the productivity of cereals remained stagnant (see Figure 2.2). The per capita food availability is also declining over time from 0.305 tons (673 lbs.) per person during 1975/76 to 0.260 tons (455 lbs.) per person in 1992/93 (UN 1997). A large number of districts, particularly in the Hills and the Mountains, are experiencing food deficits.

2.5. Socio-cultural Aspects

By religion, the vast majority of the people in Nepal are Hindus (86.5 percent) followed by Buddhists (7.8 percent) and others such as Christians and Muslims (CBS 1993). Large variation in socio-cultural characteristics of people can be observed all over the country due to its significant ecological diversity. The population is an admixture of Indo-Aryan and Tibeto-Mongoloid origins. The Hill and Mountain residents are commonly called *Pahadi* (literally the Hill residents) and the Terai residents are called *Madhise* (literally the people of *Madhesh* or Terai). Mother tongues vary by ethnicity; however, Nepali is the official language.

There is no precise information about the number of various ethnic groups in Nepal. The 1991 census recorded over 60 caste, sub-caste and ethnic and sub-ethnic groups (NESAC 1998). Karan and Ishhi (1996) categorized various ethnic groups as *Parbate* and Tarai Hindus, Tibeto-Burman groups and the others. In the Hills, the caste groups in *Parbate* Hindu are Brahmin and Chhetri, also called the High Caste Hindus, and Kami, Sunar, Sarki, and Damai are the artisan groups, also called the Low Caste Hindus (or *Dalit*). In the Terai, Brahmin, Rajput, Kayastha, and Baniya are among the High Caste Hindus and Lohar and Kumhar are the Low Castes. In the Tibeto-Burman groups are the Tibeto-Burman speaking people such as Tibetan, Sherpa, Tamang, Magar, Gurung, Thakali and Newar.

The issue of socio-cultural disparity in every sector of development has received much attention recently (see for example, NPC 2003; Pradhan and Shrestha 2005; Norwegian Refugee Council/Global IDP Project 2003; ADB 2002; NESAC 1998; Lawati 2001). Socio-culturally, people are often discriminated along caste/ethnicity and gender lines (Pradhan and Shrestha 2005; Norwegian Refugee Council/Global IDP Project 2003; ADB 2002; NESAC 1998; Lawati 2001). The High Caste Hindu, particularly Brahmin and Chhetri, and Newar caste people are among the historically privileged groups and are considered the elites in the country. It is widely believed that these groups, particularly the High Caste Hindu people, have the most access to various economic and non-economic opportunities (Acharya and Bennet 1981). In this same line, the Norwegian Refugee Council/Global IDP Project (2003) also reported a disproportionate distribution of wealth and power in favor of higher castes (for example, Brahmin, Chhetri), while lower castes (or *Dalits*) and minority ethnic groups (Hill and Tarai ethnic groups) are disproportionately affected by widespread poverty, health problems, and lack of public health awareness. Other ethnic groups are relatively disadvantaged in terms of educational achievement, income, life expectancy and overall Human Development Index (NESAC 1998; NPC 2003b).

Based on the country's Human Development Index (which is based on life expectancy at birth, adult literacy, purchasing power parity, and real GDP per capita, NESAC 1998), by caste groups, Newar, Brahmin, and Chhetri had the highest HDI of 140.73, 135.87 and 107.31, respectively. At the bottom of the hierarchy were the occupational or Low Castes or *Dalit* (for example, Kami, Damai, Sunar) with HDI of 73.62. Muslims had a HDI of 73.67, Gurung, Magar, Rai, Limbu had 92.21 and Tharu and Ahir had 96.28.

The farming practices followed vary among ethnic groups. For example, in general, Tharus and other minorities such as Darai, Kumal and Chepang people primarily follow traditional agricultural practices compared to Brahmin, Chhetri and Newar.

Moreover, Brahmin and Chhetri households keep cattle, buffalo, sheep and goats, whereas households of other ethnic groups keep these animals as well as poultry and pigs. Local ethnic communities raise these animals in large numbers compared to the High Caste Hindus or Newar because Hill and Terai Tibeto-Burmans primarily depend on livestock (Karan and Ishii 1996). Therefore, these local ethnic groups are inclined to use traditional manure (i.e., farmyard manure) on the farm. Particularly in the Chitwan Valley, farm households belonging to High Caste Hindus and Newar are relatively connected to the market and produce marketable commodities compared to those from the local ethnic groups as well as Low Caste Hindus. Although the primary occupations of individuals belonging to *Dalit* (primarily Low Caste Hindus) castes (for example, shoe making for Sharki, iron tools for Kami and sewing clothes for Damai) are different, they are also engaged in farming. These ethnic groups also differ in terms of education. Individuals belonging to the High Caste Hindu and Newar ethnic groups are generally more educated than those belonging to other ethnic groups. This difference in education by ethnicity may have important implications for the adoption of modern inputs in agriculture.

2.6. Transportation and Communication Infrastructures

With the exception of the Terai, the transportation network is still in a rudimentary stage of development in Nepal. A large part of the country is still deprived of a road network. Until 1997, only 11,714 kilometers of road were developed (Ghimire 1998). The Mahendra *Rajmarg* (Highway) traverses the Terai, and links the eastern and western parts of the country. There are a few feeder roads that connect the northern Hill and Mountain region and the southern Terai plain. Of the total 75 districts, only 65 district headquarters are accessible with roads. In many districts, accessibility is seasonal. Only 20 percent of the population had access to electricity by 2001/2002 and there was one telephone per 14 thousand people in 2002/2003. The low level of development of transportation and communication infrastructures has contributed to difficult distribution of inputs and outputs particularly in the rural areas of the Hills and the Mountain regions of Nepal.

2.7. Political History

Understanding the political history is important in understanding the past and present policy making as well as the policy implementation environment of the country. Nepal is a Hindu kingdom. The country was reigned by the Rana rulers for about 104 years that ended in 1951. Although the country was never colonized, it remained closed economically until the end of autocratic Rana rule. In 1951, a political movement also known as the Democratic Revolution of 2007 B.S. (literally *Sat Sale Kranti* in Nepali) succeeded in throwing out the Rana rule (Karan and Ishii 1996). A new democratic government was formed. The country was opened to the outside world and a few steps were taken to promote national development. The country initiated its first economic development plan in 1956. However, in 1962, the King took over the power and initiated the monarchic partyless Panchayet system, which continued for over three decades.

The popular people's movement of 1990 (also known as the People's Movement I or *Jan Andolan* I) for the Restoration of Democracy changed the partyless political system and established a multiparty democratic system in the country. After 1990, the centralized tradition of the national planning system was changed, decentralization was emphasized, and wider participation from the ruling and opposition party members, independent scholars and grass-root level organizations was sought. The country was opened to the external world in terms of trade and development. Trade liberalization, open markets, and privatization were emphasized as the vehicles of economic development. Despite these efforts, radical political parties (for example, the Communist Party (Maoist) of Nepal) that are outside the mainstream of the parliamentary system believe that this system can not satisfy the needs of people, particularly those who are at the bottom of the socioeconomic hierarchy (Norwegian Refugee Council/Global IDP Project 2003).

The country is currently experiencing a new political transition. The so called "people's war" movement initiated by the Communist Party (Maoist) of Nepal in 1996 is expanding all over the country. In their view, both the multiparty democratic system and the monarchic system have done little to address the systematic inequality of Nepalese society and underdeveloped economy (Norwegian Refugee Council/Global IDP Project 2003). They are fighting for a people's government. As a result of the political tension, between 100,000 and 200,000 people had been internally displaced by September 2003 because of both military and rebel activities (Norwegian Refugee Council/Global IDP Project 2003). Over 13,000 people have already died in the conflict at this writing.

In 2001, the political situation in the country was further affected by a royal massacre. Family members of the then King Birendra were assassinated in a royal family gathering and the present King Gyanendra came to the throne. In 2002, the present King dismissed the Prime Minister, took over the executive powers of the government and seized the power of the parliamentary political parties. Political parties considered this as a clear move against democracy. The consequence has been that the political parties were on the street operating movements against royal regression to re-establish the parliamentary system of governance. At the same time, rebels formed their own parallel governments paralyzing the central government's functioning in most of the remote districts. In February of 2005, the King formed a new government under his leadership after firing the recently appointed cabinet of Ministers including the Prime Minister. A State of Emergency was announced and the country was passing through a difficult political stage. However, with the popular people's movement (namely, People's Movement II or *Jan Andolan* II) led by the Nepal Civic Society, the government under the King was toppled and the Parliament was reinstated in May 2006. At this writing, the Parliament has already decided to seize the power of the King, the process of drafting of the interim constitution is underway, and the political dynamics is changing rapidly. Currently, all the major democratic parties (also called the Seven Party Alliance) and the Nepal Communist Party (Maoist) are in one place after reaching a historic agreement to form an interim government, conduct a Constituent Assembly election, draft a new constitution, and establish a long term peace in the country. This historic agreement popularly known as Baluwatar Talks (agreement signed on November 8, 2006) has formally ended the decade-long armed insurgency in Nepal.

This situation has disrupted the entire policy making and implementation environment of the country. However, it did not affect the survey data quality used in this study. The first wave of data was collected in 1996, when the rebels' movement was just initiated in the western part of Nepal and the second wave of data was collected in 2001, when the movement was particularly focused in the western and eastern part of the country.

2.8. Chitwan District and the Chitwan Valley

2.8.1. Geography

The Chitwan district, 2,510 square kilometer in size, is located between 83 degrees to 85 degrees east longitude and 27 degrees north latitude, with a wide ranging geo-physical environment. The average elevation is 244 meters above sea level. Bharatpur, situated at the bank of the Narayani River, is the district headquarters. Narayanghat and Parsa are the two major market centers of the district. This district is renowned for its natural resources such as dense tropical evergreen forests and many species of wild fauna such as the one-horned rhinoceros and Bengal tiger, and flora such as *Sal* (*Shorea robusta*).

The Royal Chitwan National Park stretching over an area of 932 square kilometers provides a habitat for large numbers of wild animals. The Valley is rich in water resources. Narayani, the third largest river in the country, crosses the Nepalese border into India via Chitwan. The Chitwan district is adjacent to Bihar, the northern State of India. The Nepalese traders or merchants used to get access to Indian markets via this district until a few decades ago. These days, there is no direct or convenient access to the Indian markets through this district due to the establishment of the National Park and the development of alternative transportation routes from neighboring districts.

2.8.2. Population, Economy and Agriculture

The population is increasing rapidly in the district. A population of 42,000 recorded in 1951 increased by nine-fold and reached over 354,000 in 1991. The growth rate was 3.19 percent per year over the period 1981-1991. The population increased by 2.84 percent per year during 1991-2001 and reached about 471,000 by the year 2001 (CBS 2002).

Migration, particularly from the Hills and the Mountains and from bordering Indian states is the main reason behind such a high population growth in the district (Blaikie, Cameron and Seddon 2000). According to Gurung (1998), the main reasons for internal migration in Nepal are agriculture, trade and commerce. In the Chitwan Valley, people were attracted by the free distribution of land for agricultural purposes at the beginning of the settlement and development of modern amenities and services in recent decades.

Chitwan has always received attention from the central government for political and economic reasons because of its centrality in location and proximity to Kathmandu, the capital city (Shrestha 1990). The district is considered to be one of the most economically prosperous districts in the country. The economy is primarily agriculturally based. According to the 1996 estimates, per capita purchasing power parity income in the district was US$1,301, which was higher than the national average of US$ 1,186 (NESAC 1998). Similarly, in 1996, other indicators were also above the national average - life expectancy at birth 56.5 years (national = 55.0), adult literacy 49.5 percent (national = 36.7), and mean years of schooling 2.5 (national = 2.3). Overall, the Human Development Index for the district was estimated at 0.370 compared to the national figure of 0.325 in 1996.

The Chitwan Valley is a part of the Chitwan district. It was once known as the Death Valley. Before the 1950s, it was malaria infested and was inhabited primarily by Tibetoburmese ethnic groups such as Tharu, Darai and Kumal. In 1956, the government initiated the Rapti Valley Development Project (RVDP) in the Valley with the aid from the United States Agency for International Development (USAID). The purpose was to initiate rehabilitation efforts in the Valley by eradicating malaria and inducing more migration from the Hills and the Mountains. After the initiation of the malaria eradication program, rehabilitation programs became successful. The government provided land to the migrants ranging from 4 *bighas* (1 *bigha* = 0.68 hectares or 1 hectare = 1.5 *bigha*) to 100 *bighas* by clearing the dense forest (Shrestha 1990).

Currently, the Valley is inhabited mostly by in-migrants, especially from *pahad*, i.e., the Hill and the high Hill and other Terai districts including India. There is a wide variation in ethnic composition ranging from the High Caste Hindus (for example, Brahmin and Chhetri), Low Caste Hindus (for example, Kami, Sarki, and Damai), Newar, Hill Tibetoburmese (for example, Gurung, Magar, Tamang) and Terai Tibetoburmese (for example, Tharu, Kumal and Darai).

The Chitwan Valley is divided into two parts – eastern and western. The western Chitwan Valley (Fig 2.3 and Fig. 2.4), the setting for this study, is surrounded by the Rapti river and the Royal Chitwan National Park on the south, the Narayani river on the west and north, and Barandabar forest on the east. The study area covers part of the Bharatpur municipality and 12 Village Development Committee areas surrounded by the Narayani River, Mahendra *Rajmarg* (Highway), and Royal Chitwan National Park. Narayanghat bazaar, the largest market center in the District, is the main business hub. This market center has been the center of socioeconomic change in the Valley. The national Mahendra *Rajmarg* (Highway) runs east to west via this market center. Transformation in the district has resulted in proliferation of government services, business, and wage labor jobs in Narayanghat and Chitwan by the mid-1980s (Shivakoti et al. 1999). Narayanghat bazaar also links other important cities of the country such as Kathmandu, the capital city, and Pokhara, one of the tourist hubs.

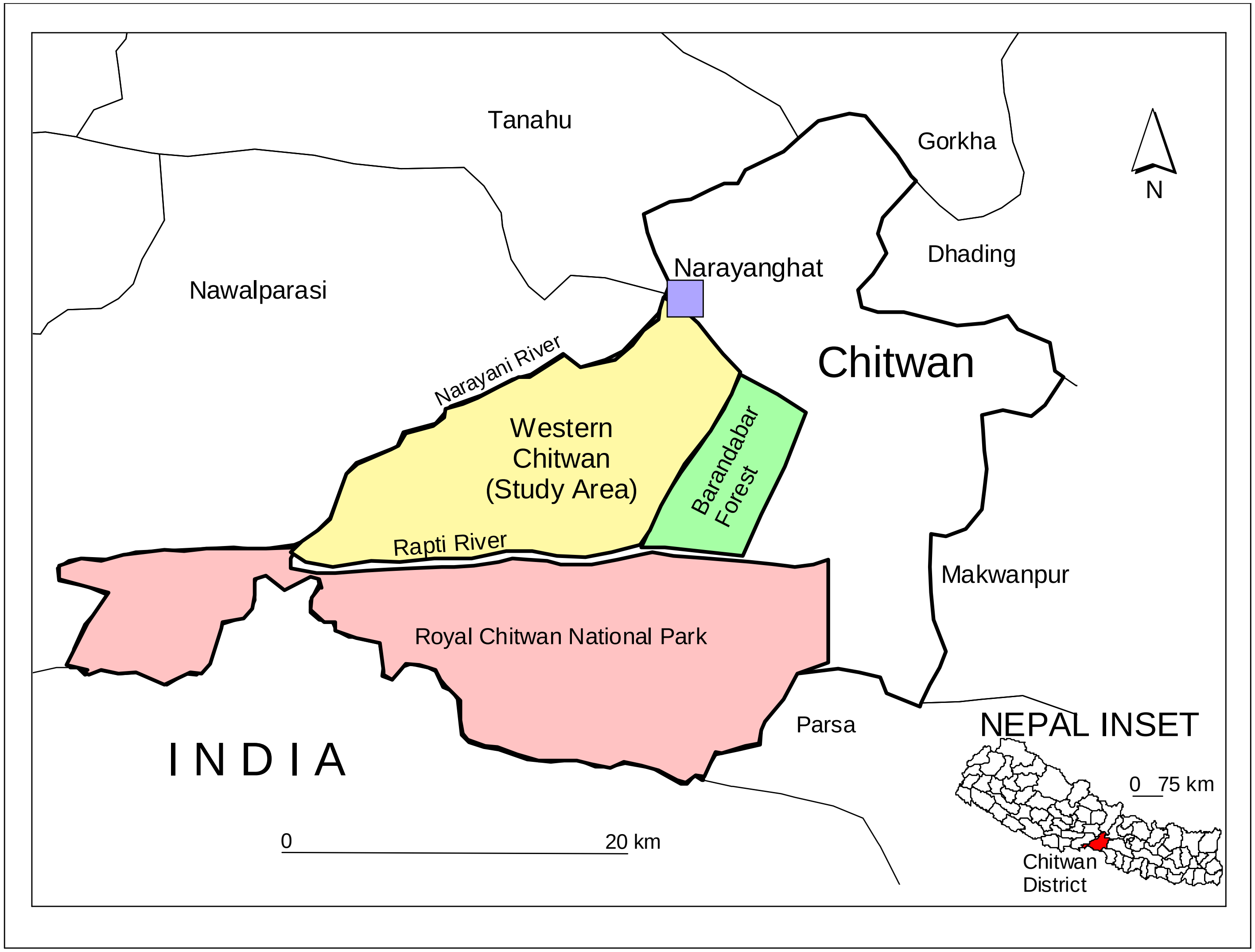
The Valley has a sub-tropical agro-climatic condition. The rainfall pattern is erratic. The weather varies between a hot and humid summer and cold winter. The Valley is renowned for its soil fertility. *Ghol* (also called the *khet* or lowland area), where the water table is high, is suitable for rice production. Usually, *Tandi* (also called *bari* or upland) land has no irrigation facility. This land is suitable for maize, wheat, and mustard cultivation. The farming system is crop-livestock integrated. Rice paddy, maize, wheat and mustard are the commonly grown crops. However, rice paddy is the important crop in terms of both area and production. It is followed by maize (corn) and wheat. Other crops produced are mustard, potato, and buckwheat.

The Valley in particular has received government attention in terms of investments in agriculture including heavy investments in irrigation, mechanization, improved seeds, pesticides, fertilizer, and new methods of production (Shivakoti and Pokharel 1989). It can be observed that agriculture in the Valley is also rapidly modernizing. According to my anecdotal experience and observation of the area for last several years (from 1983 to 2000), farmers are shifting their traditional farming system to a market-based farming system featuring vegetable and fruit production. The national figure also shows the similar trend of farmers' increasing focus toward fruits and vegetable production (Bastola 1998). Changes have also occurred in generating off-farm employment opportunities such as in trade, agri-business, tourism, and industries (Shivakoti and Pokharel 1989). The poultry industry is one of the more recently flourishing sectors in the Valley (Shrestha, Bhandari and Bhattrai 1998-99; Shrestha and Bhandari 2000). A few large scale industries such as Bottlers Nepal, Bhrikuti Paper and Pulp Industry, and many other small scale industries have been established in and around the Valley.

The Chitwan Valley was not well developed until the 1970s. There were only a few stores, some government offices, few schools and a hospital and a few medical clinics. Narayanghat became the hub with the construction of a bridge over the Narayani river and linked the eastern, western, and northern parts of Nepal in 1978 (Barber et al. 1997). At present, there are several graveled and rough motorable roads connecting rural areas of the Valley. The transportation network is relatively well developed compared to Hill, Mountain and other Terai districts of Nepal. For example, in 1995, Chitwan district with 459 kilometers of road was one among the top five districts with the highest length of road network (Ghimire 1998). Other districts are Jhapa (546 kilometers), Kathmandu (528 kilometers), and Morang (489 kilometers).

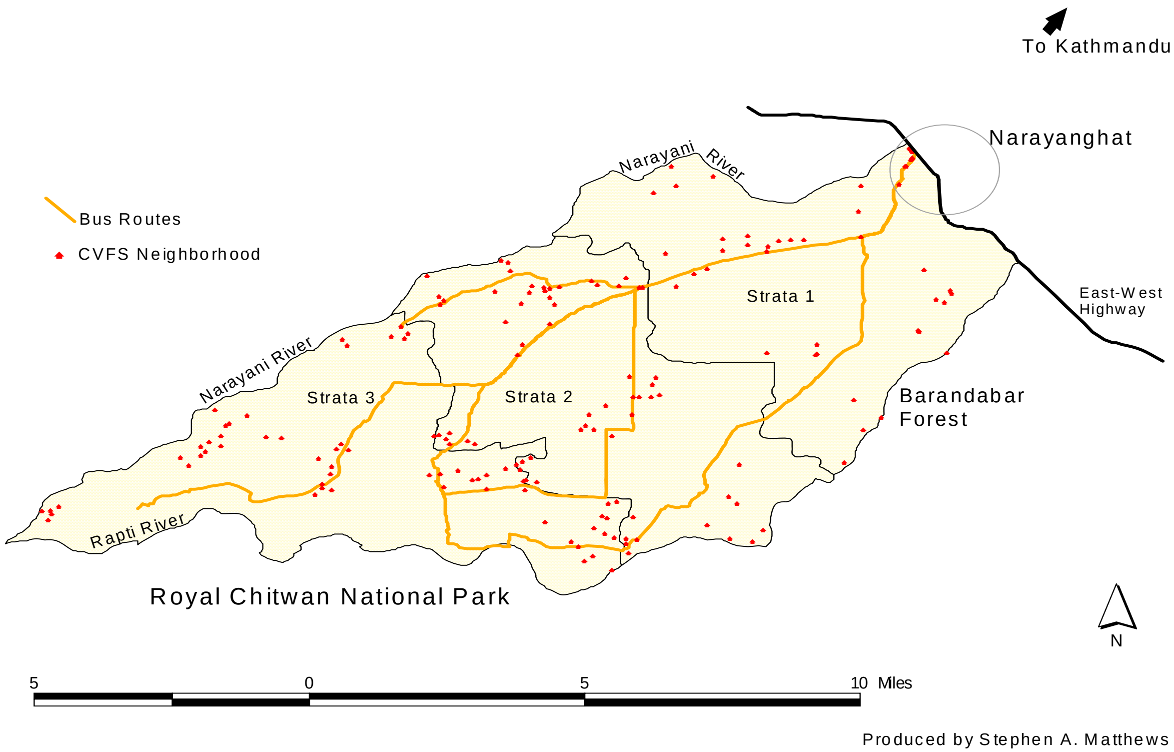
Various organizations such as the District Agricultural Development Section, Agricultural Statistics Sub-station, Agricultural Inputs Corporation, District Cooperative Section, Cooperative Union, Nepal Food Corporation, Nepal Bank Limited and Agriculture Development Bank including the Institute of Agriculture and Animal Science (IAAS) are established and provide services in the area. The role of IAAS is equally important in the research and extension of agricultural technologies in the Valley. Communications facilities such as the access to radio, television, and telephone facilities are relatively developed as compared to other parts of the country.

Fig. 2.3. Chitwan Valley Family Study Area, Nepal



Produced by Stephen A. Matthews, GIA Core
The Pennsylvania State University

Fig 2.4. Chitwan Valley Family Study Area with Neighborhoods and Bus Routes



2.9. Summary

The western Chitwan Valley is unique and suitable for this study for several reasons. This is one of the most fertile valleys of the country and is largely an agriculturally-based area. A large majority of households are dependent on farming for their livelihood. Rapid change in farming systems toward modern farming is a recent phenomenon. When this Valley was opened for rehabilitation many migrants, particularly from the Hill and Mountain districts, chose this destination for its agricultural opportunities. However, recently, a large number of individuals and farm families are changing their occupation toward non-farm activities due to the proliferation of off-farm employment opportunities. At the same time, both in-migration and out-migration of individuals as well as families is taking place. Moreover, the area is unique in the sense that the Valley provides residence to a wide range of farm households of various ethnic groups that have come from all over the country.

CHAPTER 3

THEORETICAL BACKGROUND

In this chapter I provide a theoretical basis for studying two different issues discussed in Chapter 1 – technology use in farming and occupational mobility of farm households. First, I describe a macro-perspective on the relationships between population and agriculture. Then, I provide a micro-perspective on the relationships between technology use and other factors that provide a theoretical basis to examine the effects of various factors on the use of technology in agriculture. Next, a framework is provided to explore the effects of various factors affecting the occupational mobility of farm households in the western Chitwan Valley of Nepal.

3.1. Technology Use in Agriculture – A Macro Perspective

There are two dominant paradigms that explain the relationship between population growth and agricultural development at the macro-level (Marquette and Bilsborrow 1994; Silwal 1995; Salehi-Isfahani 1993). The first is called the Malthusian paradigm originated by Thomas Robert Malthus in 1798. After a long gap, in 1965 Ester Boserup offered an alternative paradigm commonly known as the Boserup hypothesis.

Malthus believed that population increases geometrically and food supply increases arithmetically. The argument is: "as population grows, demand for food grows, which can be met by either bringing new land into cultivation or cultivating existing farmland more intensively through the application of more labor to each unit of land"

(Bilsborrow and Geores 1994:172). The first strategy of bringing new land into cultivation is generally called land extensification and the second strategy to increase food production by using more inputs, particularly labor, is called land intensification. Despite increases in agricultural production, population growth outpaces the growth of food supply. In the end, Malthusian theory holds, population growth will be checked by increased mortality due to limited food availability. However, the Malthusian perspective has been criticized by many (for example, Bilsborrow and Geores 1994; Boserup 1965, 1981; Grigg 1981; Simon 1977) on the grounds that it fails to recognize the role of technological change in agricultural dynamism (Bilsborrow and Geores 1994; Silwal 1995). Acording to Bilsborrow and Geores (1994), the technological advances, especially the use of improved agricultural techniques, have averted the “Malthusian crisis” by increasing the agricultural output per unit of labor.

In 1965, Ester Boserup forwarded an alternative view that recognizes the role of technology in agricultural development. Boserup considers population growth as a stimulant of agricultural change (Bilsborrow and Geores 1994; Boserup 1965; Jolly 1994; Silwal 1995). In her view, population pressure is the major cause of agricultural change and technology has a capacity to generate enough to support an increasing population (Boserup 1965, 1981). She argues that as population grows, the number of people per land unit rises and the return to the land per worker hour begins to fall. The population puts further pressure on the existing land to provide more food for the additional people. The search for a greater productivity per land unit leads to the adaptation or innovation of new technology and to a subsequent intensification of land use. Therefore, population growth rather than being a hindrance, it is actually a pre-requisite for agricultural development.

According to Boserup (1965:43), peasants try to adjust food production importantly through intensification defined as "a new way, namely as the gradual change towards patterns of land use which make it possible to crop a given area of land more frequently than before." In her view, as population grows relative to land, farm households have a tendency to use the land more intensively by reducing the fallow period. They also intensify land use by changing technology in ways that facilitate increasing labor per unit of land. For example, the land use system might change from forest-fallow cultivation (one or two year of crops and 20-25 years of fallow) to bush-fallow cultivation (six to ten years fallow), to short-fallow cultivation (fallow lasts one year or couple of years), to annual cropping (no fallow) and finally to a multi-cropping system (a highly intensive system of cultivation). Such a move from an extensive to highly intensive system of cultivation is also accompanied by a succession from simple tools to sophisticated tools such as improved ploughs or tractors.

Although research supports this view (for example, Bilsborrow and Geores 1994; Pingali and Binswanger 1987; Silwal 1995; Simon 1981), this perspective is also not free from criticism. It is often criticized that Boserup's hypothesis is confined to subsistence agriculture of developing countries (Kates, Hyden and Turner II 1993; Silwal 1995) and does not explain the situation of developed countries. Further, this theory is applied to study the population and agriculture relationship at the macro-level and does not explain household-level technology use.

In summary, while the Malthusian perspective considers food production as a major determinant of population growth, the Boserupian perspective, conversely, considers population pressure and population density as a major determinant of agricultural intensification. However, both of these macro-level paradigms do not explain the micro-level and particularly the household-level factors associated with the use of technology in agriculture. Since the present study is aimed at exploring demographic and other factors contributing to technology use in agriculture at the household-level, none of these aforementioned macro-level explanations are considered here. Rather the review of the macro-level explanations is provided here to help understand alternative views on the relationship between population and technology use in agriculture. I provide below a micro-perspective of technology use in agriculture particularly focusing at the household-level.

3.2. Technology Use in Agriculture – A Micro Perspective

Farm households are the primary units of decision making regarding farming practices (Ellis 1993; Feder and Umali 1993). This requires an understanding of technology adoption at the household level. In many developing countries, a household is both a producer as well as a consumer. Therefore, a farmer is always concerned with questions about what to produce, how much to produce, how to produce, how much labor to allocate, where to allocate that labor, whether or not to use purchased inputs, or which inputs to purchase, which crops to grow and so on. This idea of utilizing households as decision making units is derived from the 'new home economics,' a branch of neoclassical economic theory, which originates from Gary S. Becker (Ellis 1993). Since a household is considered as a production unit and utilizes purchased goods, services and household resources to produce a good, this theory suggests a household, not an individual as the relevant unit for analysis.

3.2.1. Concepts – Technology and Technology Use

Before presenting a theoretical framework to explore technological adoption at the household level, first, I define ‘technology’ and ‘use of technology’ in agriculture. Technology is defined as “all those methods of production which have been developed or could be developed with the existing state of scientific knowledge,” whereas a technique is “any single production method, i.e., a precise combination of inputs used to produce a given output” (Ellis 1993:224). Bartsch (1977:4) defined technology as “the application of knowledge involving the use of combinations of material inputs of a biological-chemical nature in conjunction with particular cultivation practices typically associated with such inputs…” and techniques as the methods of delivery of inputs.

Technology use is captured by the concepts of technology adoption (Godoy et al. 1998; Rauniyar and Goode 1996; Schutjer and Van der Veen 1977), innovation adoption or diffusion of innovation (Feder and Umali 1993; Feder et al. 1985; Harris 1972). The process of technology adoption is defined by Rogers (1960) as the mental processes through which an individual first becomes aware of an innovation and then to its final adoption. Feder and his colleagues further distinguished farm level (individual level) adoption from aggregate level adoption. Adoption at the individual farm level is “the degree of use of a new technology in long-run equilibrium when the farmer has full information about the new technology and its potential” (p. 256). Hence, the use of technology in agriculture is the use of new method(s) of production techniques such as the use of modern varieties (high yielding varieties or HYVs) of crops, inorganic fertilizers, pesticides, machines, and use of irrigation in order to increase production per unit area. At the aggregate level, technology adoption is defined as “the aggregate level of use of a specific new technology within a given geographical area or a given population” (p. 257).

3.2.2. Typologies of Technology

In general, agricultural technologies are grouped as labor-saving and land-saving (Boserup 1965). For example, the use of labor-saving technologies such as the use of tractors or other machines replaces human labor, whereas land-saving technologies such as industrial fertilizers and chemicals when applied increase output per unit of labor more rapidly than the output per unit of land (Boserup 1965; Bartsch 1977; Heady 1949). Schutjer and Van der Veen (1977) mentioned these technologies as labor-saving and labor-using or capital-saving. Labor-saving technologies are those where the ratio of capital to labor employed in the production processes rises, where in labor-using technologies the capital to labor ratio falls. According to Ellis (1993), these are also called capital-biased and labor-biased technologies, respectively. In Raj’s (1972) words, this definition of labor-saving or land-saving is oversimplification because use of land-saving technologies such as chemical fertilizers and pesticides may also save labor (for example, Rani and Malavia 1992) and vice versa.

A technology may be neutral or non-neutral (biased) (Ellis 1993; Schutjer and Van der Veen 1977). A neutral technology may bring a change in production but the capital-labor ratio remains constant. A non-neutral or biased technology may be either capital or labor biased, using more of one resource than another. Moreover, Feder, Just and Zilberman (1985) and Feder and Umali (1993) also mention lumpy or non-divisible and divisible technologies. A lumpy technology such as a tractor and a pumpset cannot be divided into small units, whereas divisible technology such as high yielding variety seeds or chemical fertilizers can be divided into smaller units.

Bartsch (1977) categorized technology as traditional, improved, and modern or high-yield variety. Under the traditional technology, farmers use traditional seeds, rely on rainfall for irrigation, and do not use any chemicals. Under improved technology, farmers substitute one or more traditional inputs by the improved one, such as chemical fertilizers, pesticides, improved but local varieties of seeds, and irrigation. Use of various green revolution technologies such as high-yielding varieties of seeds, chemical fertilizers, well controlled irrigation, herbicides and pesticides in conjunction with the cultivation practices recommended for their optimum use are considered under modern technology category. He classified various techniques as traditional, for example, the use of traditional techniques such as unassisted human or human and animal power; intermediate, for example, the use of substitutes of traditional techniques by improved ones but the same power source; and mechanized, for example, use of fully mechanized power. The distinction among these techniques is primarily on the source of power used and associated equipment.

Borrowing from Heady (1949), Bartsch (1977) mentioned two important distinctions of innovations: mechanical and biological-chemical. A mechanical innovation or technology substitutes labor, but its use does not change plant physiology. However, a biological-chemical innovation affects plant growth and brings changes in total production, for instance, use of fertilizer or pesticide. According to Bartsch

(1977:4), this classification of bio-chemical and mechanical innovation “provides an eminently suitable means of assessing employment effects of different technical alternatives in the agriculture of developing countries.” Similarly, De Janvry (1978) classified technologies into four categories. A mechanical technology included tractors, harvesters, and windmills; a biological technology included hybrid seeds; a chemical technology referred to the use of fertilizers and pesticides, and an agronomic technology included cultural practices and crop management techniques.

In summary, in this study I conceptualize technology adoption as the use of a combination of modern inputs such as tractors, pumpsets, improved implements, chemical fertilizers and pesticides used by the farmers. Borrowing from Heady’s and Bartsch’s classification discussed earlier, I have grouped these technological inputs into two packages: (i) a bio-chemical package that includes the use of chemical fertilizers and pesticides, and (ii) a mechanical package that includes the use of tractors, pumpsets, and improved farm implements. Since both of these technology groupings are labor-saving in nature, the presence of family labor may have an important implication for the adoption of these technologies.

The rationale behind this bio-chemical versus mechanical classification is twofold. First, biologically, the effects of these two technology packages on plant growth are different. While the use of mechanical technology increases agricultural production by improving the physical condition of soil and by timely completion of agronomic operations, the use of bio-chemical technologies increase production by directly affecting plant physiology. Therefore, the factors contributing to the adoption of these two technological packages by farm households could be different. From a policy perspective, while the production and distribution of mechanical technology is carried out under the management and supervision of the Agricultural Tools Company (NPC 2003a), this function for bio-chemical technology such as fertilizer and pesticides is carried out by the Agricultural Inputs Corporation and the Fertilizer Unit of the Department of Agriculture. The outcome of this research can be helpful in providing feedback specifically to these institutions.

3.2.3. Explanations of the Use of Technology in Agriculture

Everett M. Rogers provided the theory of diffusion of new ideas (Rogers 1960). He emphasized the role of communication in the diffusion of new ideas and subsequent adoption behaviors of farmers. According to Rogers, diffusion and adoption of new ideas takes place through five different stages: awareness, interest, evaluation, trial and final adoption. He also explained some of the factors affecting the rate of adoption. For example, if a new idea is affordable, simple, divisible (can be tried in a small amount), visible (outputs can be seen) and compatible to the farmer's condition, the rate of adoption is faster. He further categorized farmers based on when they adopt new ideas – innovators, early adopters, early majority, late majority, and laggards. For example, the innovators are the first farmers to adopt a new idea, whereas the laggards are those who adopt any idea last. Rogers also described important characteristics of various categories of these farmers. For example, innovators have leadership quality, large size of farm, educated, relatively younger, have high social status, and use most advanced communication techniques such as contact with research communities, and refer to research bulletins and farm magazines compared to other categories of farmers. This theory of diffusion of innovation is important in conceptualizing the adoption of new technologies in agriculture.

Besides this, there is no single specific theory to provide explanations behind technology use by farm households. Therefore, Godoy et al. (1998) pointed out the need to develop a theory of adoption. Researchers, for example, Schutjer and Van der Veen (1977), Feder et al. (1985), Feder and Umali (1993) and Rauniyar and Goode (1996) provide some micro-level theoretical explanations behind the use of technology in agriculture. Moreover, most of the theoretical as well as empirical work focuses on economic factors associated with technology adoption. The focus of this study is on household-level demographic factors, particularly the availability of family labor and other socioeconomic and neighborhood contextual factors.

3.2.3.1. Demographic Characteristics and Technology Use

a. Family Labor Availability and Technology Use. It is often argued that the availability of labor influences decisions to adopt technology in agriculture (Feder et al. 1985; Karablieh and Salem 2003; Schutjer and Van der Veen 1977). As a household is assumed to increase production by appropriate use of resources including family labor, the presence of working-age males and females might have important implications for technology adoption in a setting where household members are the major source of farm labor. For example, a labor-using technology such as the cultivation of high yielding variety seeds (HYVs) demands more labor for land preparation, regular irrigation, fertilization, and for other activities as compared to traditional seeds. A household with limited labor may not be motivated to adopt such a technology. Empirical evidence also suggests that short supply of family labor was associated with the non-adoption of HYVs in India (Harris 1972). In this same line, Rauniyar and Goode (1996), in their study of Swaziland, hypothesized that households with a large quantity of family labor are less likely to use labor-saving technologies but are more likely to use labor-intensive technologies.

Moreover, it is also understood that some of the agricultural operations are gender specific (Acharya and Bennet 1981; Agarwal 1992; Sachs 1996; Bhandari et al. 1996; Boserup 1971, 1990; Prasad and Singh 1992; Rani and Malaviya 1992; Singh et al. 1992). For example, Boserup (1971, 1990) indicated that in Africa, plowing of fields is primarily done by males and hoeing or weeding is done by females. This situation is not an exception in the Indian and the Nepalese context. For example, in India, land preparation for crop cultivation, irrigation, and threshing of grains are predominantly performed by men, whereas transplanting of rice, sowing, manuring, weeding, intercultural operations, and harvesting are primarily done by women (Agarwal 1992). This situation also holds true in the Nepalese context.

It is likely that use of technology may replace gender-specific labor requirements in some specific sorts of operations while demanding more labor on other operations. For example, women’s labor time would be demanded in transplanting of rice and weeding if irrigation is provided (Boserup 1971). Sachs (1996) also reported that labor intensive tasks in agriculture such as rice transplanting, weeding, and harvesting are often performed by women. Bina Agarwal (1992) also provided evidence from India that female labor demand increased due to the adoption of HYV rice. Therefore, the presence of gender-specific labor in a household is expected to affect the use of labor-saving technology in farming.

Below I describe how family labor availability affects technology use by a household by technology packages. As mentioned earlier, I have categorized these technologies into two packages: (1) biological-chemical technology package that includes the use of chemical fertilizers and pesticides, and (2) mechanical technology package that includes the use of tractors, pumpsets, and improved farm implements. Since the data set analyzed here does not provide information on high yielding variety use, I cannot include this input with the first technology package.

(i) Family Labor Availability and the Use of Bio-Chemical Technology. The use of biological-chemical technology, here, refers to the use of chemical fertilizers and pesticides (insecticides and herbicides both). In Nepal, farmyard manure (FYM) or compost (also called organic manure) is the commonly used soil nutrient replenishing material. Recently, the use of chemical fertilizer is increasing, however. Techniques of fertilizer application vary in Asia, for example, farmyard manure application by hand, green manure application right in the field by cutting green plants, and plowing them into the soil, and chemical fertilizer application by hand or using a scoop and basket (Bartsch 1977). In some countries, fertilizer drills, seed drills, and row planter equipment by tractors are used to apply chemical fertilizers. In Nepal, manual application by hand is a commonly used technique.

Comparative studies on labor requirements by various methods of manure application are scarce. Moreover, the available evidence is not conclusive. In Swaziland, the use of chemical fertilizer is considered to be a labor-intensive technology, where it is frequently used as basal-dose and top-dressing (Rauniyar and Goode 1996). Arnon (1987) also reported that the application of fertilizers may increase labor demand due to the need for more frequent and intensive weeding. In India, Bartsch (1977) also indicated similar findings. However, these studies have not compared labor requirements of chemical fertilizer application with traditional application of manure.

In the Nepalese context in general, and the Chitwan Valley in particular, the application of FYM demands a much higher level of human labor as compared to the use of chemical fertilizers. This is because a household is required to keep livestock to produce manure for the field, which demands regular supply of labor for the care and management of animals. Second, the barn has to be cleaned and compost has to be prepared. Third, prepared compost has to be carried out to the field in baskets or carts and has to be applied in each and every field. It requires a significant amount of labor as compared to buying, storing, and applying of chemical fertilizer in the field.

Application of FYM is primarily performed by females. Males and children also perform this task. Chemical fertilizers, in general, are applied by males, however. If compared to FYM, the use of chemical fertilizers is labor-saving. Therefore, it is expected that *the availability of family labor in a household should have a negative impact on the use of chemical fertilizers*.

The application of herbicides and insecticides also replaces manual labor. Herbicides are used for controlling weed growth in the crop fields, whereas insecticides and pesticides are used for controlling insects and diseases. Manual weeding of unwanted plants is a common practice in the Valley and the task of weeding is specifically performed by women. Therefore, the use of herbicides particularly replaces female time.

For example, Rani and Malavia (1992) reported that one acre of land required 12.42 days for manual weeding by women in India. When herbicides were applied to control weeds, the time required decreased to 0.42 days per acre.

In Asian agriculture, four basic types of methods are followed to protect disease and insects – cultural (crop rotation, fallowing), physical and mechanical (eradication and scaring away pests), biological (breeding of insect or disease resistant varieties) and chemical method (use of insecticides and pesticides) (Bartsch 1977). Pesticide (insecticide) application is relatively more common in the Chitwan Valley compared to the use of herbicides. Moreover, in the Chitwan Valley, the physical and mechanical methods are used to apply insecticides/herbicides followed by chemical methods. Bartsch further noted that the physical-mechanical method of controlling pests is purely manual and is highly labor-intensive. Since both weeding and roughing of disease and insect infested plants are primarily performed by females, *the availability of working-age females in a household is expected to affect negatively the use of herbicides and pesticides*.

(ii) Family Labor Availability and the Use of Mechanical Technology. Mechanical technology increases work efficiency and therefore, the productivity of labor. Examples of mechanical technologies are tractors, pumpsets, harvesters, threshers and improved farm implements. It is understood that the use of tractors in agriculture replaces farm labor (Agarwal 1983; Schutjer and Van der Veen 1977). For example, in one study in India, the use of a tractor required only one-fifth the labor that was needed when using a bullock (Agarwal 1983). In her study, Agarwal found that there was a considerable replacement of human labor by tractor power. Similar findings were reported by Bartsch

(1977). However, these studies have not examined whether household-level labor shortage motivates farm households to use tractors. Purvis (1968) and Alivar (1972) (cited by Schutjer and Van der Veen 1977), concluded that the use of mechanical power helps overcome peak period labor demand and therefore, labor shortage is a strong motivation for the use of mechanical power in crop production. Similarly, a study conducted in a semi-arid region of Tunisia concluded that “the higher the rate of household labor, the lower the hours of tractor use per hectare” (Gana and Khaldi 1990:209).

In this study, I argue that the availability of working-age family labor per unit of cultivated land is an appropriate measure of the labor-saving technology adoption decision. A farmer assesses the actual labor requirements to cultivate a given piece of farmland and also finds out how much of it can be actually fulfilled from within the household. If the labor requirement cannot be fulfilled from within and cannot be hired from outside, the farmer is motivated to use labor-saving modern inputs instead of leaving his fields uncultivated. Conversely, if a farm household has enough family labor to carry out crop production activities, the household would be motivated to increase farm production by intensively using its labor rather than using labor-saving technologies. The use of labor-saving technologies would expel already available farm labor, and the available worker remains unemployed. Therefore, in general, I hypothesize that *increased availability of working-age family members per unit of cultivated land reduces the likelihood of labor-saving technology use in agriculture.* A similar measure of per-hectare family labor potential was used by Rauniyar and Goode (1996) in their study of technology adoption in Swaziland. They also expected a negative effect of family labor potential per unit land on technology adoption.

Land preparation for crop cultivation is generally performed by using human and animal labor. In Nepal, men are solely responsible for plowing of land by using bullocks. The use of bullocks by women to plow the field is a cultural taboo in most parts of the country. If there is a shortage of male labor in a household, alternatives are either to hire bullocks and a man (also called a *hali* in Nepali) or to hire a tractor. Given the shortage of working-age males, a household may opt to hire a tractor because of its certain benefits such as timeliness, deep plowing, and no need to take care of food preparation for the *hali* and fodder for the bullock. The shift in land preparation activity from human and bullock labor to a tractor replaces male labor not female labor. Therefore, it is expected that *a farm household with relatively more working-age males per unit of cultivated land is less likely to use a tractor*. However, a female has to cook food for the *hali* and sometimes has to work behind the plough to pulverize the soil, if a bullock is used. The use of a tractor does not require female labor. However, studies are scarce about the effect of female labor availability on the use of tractors.

Use of rainfall and canal water (gravity flow) is the common method used in irrigating crop fields in Asia. Nepal in general and Chitwan Valley in particular are not exceptions to this situation. In the Chitwan Valley, crop fields are usually irrigated by using canal water during the monsoon (rainy) season. However, where canal water cannot be delivered to the field, a pumpset is used. Water is lifted either from the canal or from the deep wells with the help of a pumpset and then applied to the field crops. However, during dry seasons (winter and summer), the irrigation canals are generally dry and the pumpset is the only source for regular and assured supply of water.

Evidence is limited on whether the use of a pumpset is a labor-saving or a labor-using technology as compared to gravity irrigation. One thing should be clear that when gravity irrigation is feasible, there is no need for a pumpset. But when gravity irrigation cannot be applied to the field, pumpsets are used for lifting water from the canals or wells. Moreover, since it is used to ease manual work and increase efficiency it is plausible to think that pumpset irrigation is labor-saving.

There are findings that traditional methods such as the use of the Persian wheel (an animal powered wheel with pots) and *charsa* (use of bullocks for lifting water from the well), commonly used methods in India, are labor-intensive as compared to pumpset irrigation (Bartsch 1977). For example, Billings and Singh (cited in Agarwal 1983) in their study of India, reported that the substitution of a pumpset for Persian wheels reduces human labor requirement to one-fourth of the previous level. Bartsch further reported that manual labor is greatly reduced when a pumpset is used as compared to gravity flow. In Nepal, males usually perform the task of irrigating crop fields. Therefore, use of pumpset irrigation replaces male labor. In other words, it is argued that *households with fewer male laborers per unit of cultivated land may be more likely to use a pumpset.*

Among the other implements used by the farmers of the Chitwan Valley are corn shellers, sprayers and chaff cutters. Corn shellers are used for loosening grains from corn, whereas sprayers are used for spraying chemicals such as pesticides and herbicides. A chaff cutter is used for cutting straw or dried fodder into small pieces to be used for livestock. Loosening of corn grains is commonly a manual job in the Valley. Although female labor is generally used for this purpose, male labor is equally used whenever needed. A corn sheller also is increasingly being used by some farm households for the purpose. It is relatively easier and faster to use a corn sheller. Similarly, a chaff cutter saves males' time as compared to those of females. The use of a sprayer generally increases male labor and saves female labor by reducing their time for weeding or removing diseased plants from the field. But its use is infrequent in Nepal. It is, therefore, hypothesized that *the availability of family labor reduces the likelihood of using mechanical equipment in agriculture.*

b. Age of the Head of the Household. Age of the head of the household is considered an important factor affecting the adoption of new technology. It is generally believed that older age individuals are relatively more resistant to change compared to their younger age counterparts. Rogers (1960) indicated that laggards, farmers who are last to adopt new innovations, are among the oldest farmers who often stubbornly resist adopting new ideas. They are accustomed to practices that have been used for a long time. Moreover, they are less educated, rely less on external information, and have less exposure to communication media (Diederen et al. 2003). Diederen et al. (2003) found a negative relationship between farmer's age and their innovativeness in the Netherlands. Since most decisions in a farm household in Nepal are made by the head of the household, I argue that the *older the head of the household, the less likely a farm household will use new technologies in farming*.

c. Migration of Family Member(s). Migration of one or more members from a farm household might influence technology use in crop production in a variety of ways. First, a household expects a higher return from migration of one or more individuals in terms of remittances or other kinds of transfers relative to the income obtained from the farm. The income earned from migration and remittances can be used to purchase various inputs required in farming. Second, as an individual migrates, labor supply in the farm is reduced. In Samoa, Muliaina (2003) reported that migration of a family member in search of employment was one of the reasons for the shortage of labor on the farm. Reduced labor supply in a household might influence the use of a labor-saving technology. Third, as individuals migrate, they are exposed to new circumstances. The exposure of an individual might also increase the likelihood of a farm family to use technologies in crop production. Rogers (1960) pointed out that early adopters of new ideas are more likely to have social contacts, for example, extra-community friendships and travel experiences as compared to late adopters or laggards. Therefore, it is hypothesized that *migration of a family member increases the likelihood of using technologies in farming*.

3.2.3.2 Socioeconomic Characteristics and Technology Use

a. Size and Quality of Cultivated Land. Adoption of improved technology in agriculture depends on farm size (Feder and O'Mara 1981; Feder et al. 1985; Feder and Umali 1993; Rauniyar and Goode 1996; Diederen et al. 2003). It is argued that small farmers are relatively more risk averse compared to large farmers because they are poor and have less ability to withstand the pressure of changing agricultural output and income due to lack of capital (Schutjer and Van der Veen 1977). Moreover, large farmers can better spread the fixed costs that arise due to a new technology over a larger output than small farmers (Rauniyar and Goode 1996). Further, large farmers may enjoy political power in getting access to services such as credit to use technologies.

In their review, Schutjer and Van der Veen (1977), however, reported a mixed relationship between farm size and technology adoption due to the complex relationship between these two variables. For example, less divisible technologies such as tractors and pumpsets are relatively less accessible to small farmers compared to large farmers. However, in their view, land size should not be a constraint for the adoption of more divisible technologies such as fertilizers, high yielding variety seeds, and pesticides.

The World Bank (1998) reported that fewer poor households in Nepal had access to good quality land called *khet*, had less access to irrigation, and used relatively low levels of fertilizers compared to the farmers of higher socioeconomic status. Because small farm families produce for subsistence, they have almost no or low savings potential to make further investment in technology adoption or land improvement (Pant and Jain 1969). Therefore, in the Nepalese context, a positive relationship between size of cultivated land and technology use can be expected. However, in a context where the labor market is not well developed for agricultural activities such as land preparation, irrigation, weeding, and pesticide application, I argue that availability of family labor per unit of cultivated land is a more appropriate measure of labor-saving technology adoption decision than absolute size of labor force and land size for reasons described earlier.

Quality of land also matters in technology adoption. Feder et al. (1985) note that better physical environment of the farm land such as better soil quality and water availability increases farm income by using modern technologies. *Bari* (also called *tandi*) and *khet* land (also called *ghol)* are two types of cultivated lands found in the Chitwan Valley. The *bari* land is upland and usually not irrigated. It is generally not suitable for rice cultivation unless irrigation is provided. The *khet* land is a low lying area and can be irrigated. It is good for rice planting. The *khet* land is considered good quality land in terms of production and price compared to the *bari* land. Therefore, I hypothesize that *farmers with good quality land (khet land) are more likely to use technologies compared to those who own bari land.* Moreover, the use of inputs such as fertilizers depends on the availability of irrigation. Therefore, it is also hypothesized that *use of inputs is positively associated with the availability of irrigated land.*

b. Socioeconomic Status. Investment is needed to assure a supply of improved inputs in order to increase income from farming. Because improved inputs have to be purchased from the market, lack of capital is considered one of the important obstacles to technology use in developing countries (APP 1995; Feder et al. 1985; Pant and Jain 1969; Schutjer and Van der Veen 1977). Therefore, households with higher socioeconomic status or higher level of income are more likely to use technology in agriculture.

Land is the most important production resource in an agricultural setting. Therefore, private ownership of land is considered one of the important determinants of socioeconomic status (De Janvry 1981; Findley 1987; Datta 1998). In Bangladesh, Datta (1998) reported that ownership and control over this most vital resource increases control over other resources such as income earned from land, political power, and access to other institutions, for example, banks. Therefore, theoretically, it is expected that land owner farmers are more likely to use technologies than tenants or sharecroppers (Schutjer and Van der Veen 1977). If a tenant or a sharecropper adopts a new technology, costs and risks associated with the adoption of new technology are the responsibilities of tenants or sharecroppers, whereas they have to share the output with the landlord (Harris 1972). On the other hand, land owners can take full advantage of investment in new technology. Because land owners obtain returns from their land, labor, and investment (capital), whereas tenants receive returns from their labor, management skills, and capital used in the production process (Stokes and Schutjer, 1984).

In the South Asian context, Myrdal (1968) pointed out that a tenant or a sharecropper cannot initiate output-raising investments because of insecurity of the tenure. In his view, as the rent of tenurial arrangement varies by gross output, but not by net return, half of the output goes to the landlord as a free gift and therefore, this system of land tenure "has a strong built-in deterrent to intensified cultivation" (p. 1065). Moreover, there is no basis to control the amount of rent, which is primarily based on productivity, local custom, and population pressure (Mcdougal 1968 cited by Regmi 1976). In some other cases, the return from the investment is expected to exceed the tenure period. There is also a chance that a landlord breaks the contract and rents it to others after land improvement.

Schutjer and Van der Veen (1977), in their review, reported inconsistent empirical evidence of the relationships between land ownership and technology use, however. They reported that land tenancy acts as an intervening variable in the adoption process and influences adoption indirectly through access to credit, purchased inputs, and product markets and technical information. Pitt and Sumodinningrat (1991) also observed a negative relationship between land ownership and adoption of high yielding variety in Indonesia. Their argument is that "[l]arger ownership of land reduces the likelihood of HYV adoption, consistent with risk aversion increasing in wealth" (Pp. 466-467).

In Nepal, it has been argued that insecure tenure is an obstacle to land improvement (Pant and Jain 1969; Shrestha 1966). Historically, Regmi (1976) reported that landownership in Nepal assumed the form of rent-collection function. A land owner could rent his land to the tenant and could collect rent out of it. There was a direct relationship between the land owner and the state, but not with the actual cultivator who therefore had no incentive to invest in land improvement. The dual ownership of land between the owner and the tenant is another important obstacle behind agricultural development in the country (NESAC 19980). This is the system where the landowner has the ownership right, whereas tenants have use rights. A tenant shares the output to the owner which is usually fixed at approximately half of the average produce (Regmi 1971). However, this form of landownership provided little incentive to both of the parties – landowners and tenants. The tenants with insecure tenancy rights hesitated to improve land permanently due to uncertainty of land rights, whereas the landowners could receive the output simply by renting out land and without sharing any of the cost of production (Shrestha 1966). Realizing this problem, the government has emphasized the elimination of dual land ownership in Nepal (NPC 1998).

Insecurity of land rights also constrains the access to formal (institutional) credit and extension facilities, thus hindering the use of improved technologies. This is because collateral is required in the form of land (land right certificate) or other property to obtain credit from most institutional sources (NESAC 1998). This requirement of collateral has deprived small, marginal and landless farmers of access to formal credit sources, where the interest rate is quite low as compared to the interest rate of non-institutional sources (private sources). Although the government has initiated group guarantee loans that do not require collateral (for example, through the Small Farmers Development Programs of the Agricultural Development Bank), a farmer who is not eligible for membership (eligibility requires less than a half hectare of land) does not belong to any group and therefore, is deprived of this opportunity. Moreover, such programs have not been initiated everywhere in the country. Therefore, there is a belief that uses of green revolution technologies that are material-based and labor-saving favor those who control the means of production, here land, other than labor (Shrestha 1990). Consequently, in Nepal and in the Chitwan Valley in particular, I expect that *land owners or owner cultivators are more likely to use agricultural technologies than are tenants or sharecroppers*.

c. Land Fragmentation. Land fragmentation is another important factor affecting the use of technology (Myrdal 1968; Schutjer and Van der Veen 1977). Fragmentation of holding reduces the size of cultivated land, on the one hand, and separates land parcels into different pieces on the other, making it difficult to use lumpy technologies such as tractors. In addition, scattered holdings increase the burden of applying fertilizers or in moving tools from one place to another place. For example, Myrdal (1968) notes that excessive fragmentation of land makes irrigation unfeasible.

Gebeyehu (1995) also believes land fragmentation is one of the obstacles to agricultural development in Ethiopia. He notes that land fragmentation involves long distance travel and therefore, there is a waste of time and effort in moving labor, animals, and harvested crops. It also makes regular farm supervision difficult. However, Gebeyehu (1995) did not find evidence of the effect of distance to farm on cropping patterns and land-use intensity in Ethiopia. Rather, farmers in Ethiopia perceived positive benefits of fragmentation as they might have different quality of land and can plant different crops according to the suitability of land and household needs. For them, fragmentation also works as a risk-averting mechanism. If different crops are planted in different parcels, crop loss can be saved from uncertain weather, pests, diseases, and other natural calamities due to their differential resistance capacity.

In Nepal, on average, about 4.0 parcels of land per household were recorded in 1991. Moreover, the average number of parcels per hectare of land is 4.2 in the country (Chapagain 2001). Land fragmentation is further expected to increase over time due to the land inheritance system and reduce a household's access to cultivated land. Parental property, including farmland, is divided among heirs during household fission. In Nepalese agriculture, land fragmentation is considered as one of the important obstacles to agricultural production improvement (ANZDEC Ltd. 2002; Chapagain 2001; Chitrakar 1990; Pant and Jain 1969). Fragmentation of holdings increases the number of parcels to be taken care of thus, reducing the care and management of field crops. It also makes transportation of machines and inputs difficult. Moreover, it also reduces the size of farms. Therefore, it is hypothesized that *the greater the number of parcels of land in a household, the lower the use of improved technology in agriculture.*

d. Livestock Ownership. The role of livestock is significant in Nepalese agriculture. A household keeps livestock not only for animal protein and as a source of income, they are also kept for draft power and farmyard manure (FYM). Traditionally, farms are fertilized with farmyard manure. A survey recently conducted in Nepal reported that there is a negative relationship between the number of large ruminants owned by the farm household and the probability of the use of fertilizer (Ministry of Agriculture and Cooperatives 2003). Therefore, it is further hypothesized that *households that keep large animals (e.g., cattle, buffalo, sheep and goats) are less likely to use chemical fertilizer*.

e. Education of the Head of the Household. It is recognized that education of family member(s) is important in technology adoption decisions (Feder et al. 1985; Feder and Umali 1993; Foster and Rowenzweig 1996; Lin 1991; Rauniyar and Goode 1996; Rogers 1960). Rogers (1960) mentioned that laggards (last category of farmers to adopt new ideas) have the least education as compared to innovators or early adopters.

Education increases the value of entrepreneurial ability of a farmer (Feder et al. 1985). Rauniyar and Goode (1996), in their study of Swaziland, observed that per capita education available was important in differentiating farmers in the advanced adopter class from the low and moderate adopter classes. The farmers of the advanced adopter class with relatively more education were more likely to adopt various agricultural technologies compared to low and moderate adopters. Harris (1972) also cited the report of the National Council of Applied Economics Research that the acquisition of primary education had a significant effect on fertilizer use in India.

Rosenzweig (1982) also claimed that the adoption of new technology such as high yielding variety technology depends on education. In his view, education increases the efficiency of HYV technology adoption especially through reducing the cost of acquiring new technology and increasing access to credit. Pitt and Sumodinningrat (1991) believed that education may also reduce the informational costs attached to the adoption of new technology. However, in their study in Indonesia, they found that education had a positive but not a significant effect on the adoption of HYVs. Godoy et al. (1998) also did not find a significant influence of the level of education of the household head on the adoption of chemical fertilizers and insecticides in Bolivia. The reason suggested was that income and education were strongly correlated. They further tested for the joint statistical significance of both variables using a log-likelihood test and found that income and education both mattered in technology adoption. Lin (1991), however, found a strong and positive effect of the education of the household head on the probability of adoption and the intensity of adoption of hybrid rice in China.

Shrestha (1966) and Pant and Jain (1969) emphasized the importance of education in agricultural development in Nepal. They reported that although Nepalese farmers are as efficient as other fellow cultivators in the advanced countries, because of “their conservative outlook and illiteracy they are reluctant to use good seeds, compost manures, chemical fertilizers, improved techniques of cultivation, irrigation water, pesticides…” (Pant and Jain 1969:43). Although much has changed by now in terms of education and adoption of technologies, I expect that education still plays a significant role in the adoption of technologies. Moreover, education in rural settings is one of the sources of information for farmers in changing their traditional attitudes and beliefs. It also helps increase the access to rural financial institutions as well as extension services as based on personal experience, educated individuals do not hesitate to contact these institutions and face fewer barriers related to literacy. It changes values and aspirations of farmers thereby encouraging them to adopt new techniques (Arnon 1987). Given this background, I argue that *education of the head of the household positively influences technology use in agriculture.*

f. Access to Information. It is believed that farmers who have relatively better access to information sources are more likely to use agricultural technologies (Rauniyar and Goode 1996; Rogers 1960). Access to information increases the exposure of a farmer to information regarding a new technology. According to Feder et al. (1985), the access to information reduces the subjective uncertainty perceived by farmers that comes from an unfamiliar technique that might be more uncertain than a familiar one and encourages them to adopt a new technology. Rogers (1960) pointed out that laggards, the last category of farmers to adopt innovation, have very limited access to sources of information such as neighbors and friends, whereas those innovators or early adopters used other sources such as radio, television, magazines, research bulletins, and other extension agents. Accordingly, I also hypothesize that *the access to information sources increases the likelihood of technology adoption in farming.*

g. Ethnicity/Caste. Feder et al. (1985) argued that researchers have basically focused on the size of cultivated holding in technological adoption studies neglecting the importance of tribal groups or indigenous groups with few or weak links to the market. Recognizing this fact, Godoy et al. (1998) suggested that in areas where people are not fully integrated into market economies, the study of adoption of new technologies should take into account the importance of diversity in culture, villages, and households. Using data from Yuracare and Mojeno villages of Bolivia, South America, Godoy and his colleagues (1998) observed that the adoption of new technologies differed by ethnicity. According to their findings, although the Mojeno were relatively better integrated with the market, received better facilities such as education, agricultural extension, and credit facilities from the government and non-governmental organizations as compared to the Yuracare groups, the Mojeno were less likely to adopt technologies such as chemical fertilizer and pesticides as compared to Yuracare groups. Similarly, I expect that the use of technology in agriculture may vary by ethnicity in the western Chitwan Valley of Nepal.

In the Chitwan Valley, people of various ethnic backgrounds such as Brahmin, Chhetri, Newar, Gurung, Magar, Tharu, and many others reside and farm. Some ethnic groups such as the Tharu, Kumal, and Darai that belong to the Terai Tibetoburmese group, are indigenous to this setting and practice mostly traditional farming, whereas other ethnic groups tend to be in-migrants and vary in their farming practices, which should be an indication of differential adoption of technologies by ethnicity. Moreover, households belonging to the Terai Tibetoburmese group are relatively less integrated to market economy compared to those of other ethnic groups. Since Brahmin and Chhetri belong to the High Caste Hindu and are considered among the elites compared to other ethnic groups, I hypothesize that *households belonging to the High Caste Hindu are more likely to use technologies as compared to the other ethnic groups*.

3.2.3.3. Neighborhood Characteristics and Technology Use

a. Community Services. Community contexts such as the access to institutions like banks, cooperatives, Small Farmer Development Programs, markets, and transportation facilities also influence the use of technology in agriculture. For example, use of technology requires capital investment to buy or hire tractors, purchase fertilizers, pesticides, seeds and other farm implements. The capital needed for investment has to come from farmers' own savings or from institutional or non-institutional credit sources. Lack of capital and credit has been considered one of the important bottlenecks for agricultural development in the country (Pant and Jain 1969). As most of the farmers in Nepal are in subsistence and have almost no or low savings, access to credit sources could be an important source of additional capital. Recognizing the problem, the

Agricultural Perspective Plan has emphasized the role of the Agricultural Development Bank and other banking institutions to provide loans to needy farmers (APP 1995; NPC 1998, 2003a). Therefore, access to credit sources could be an advantage in buying and using technologies.

In Nepal and the Chitwan Valley, the Agricultural Development Bank, and other banks such as Nepal Commercial Bank (Nepal Vanijya Bank) and Nepal Bank Limited provide credit to farmers for agricultural purposes. Therefore, I consider access to these institutions and facilities an important factor of technology use. I expect that *proximity to the banks increases the likelihood of borrowing farm credit, which increases the likelihood of using improved technologies in farming*. Moreover, untimely and inadequate availability of inputs such as fertilizers, pesticides, and other inputs have been considered one of the important barriers to technology use in agriculture in Nepal (APP 1995; NPC 1998 2003a; Pant and Jain 1969). Agricultural Cooperatives established in and around the Chitwan Valley provide fertilizers, pesticides, and high yielding variety seeds to farmers. Therefore, I expect that *access to Cooperatives increases the likelihood of using fertilizers or pesticides by the farmers.*

Access to transportation facilities is equally important in moving inputs and outputs efficiently. Harris (1972) pointed out the significance of transportation and communication facilities on the adoption process. He noted that road density is positively associated with fertilizer use. It is realized that poor road access is one of the important factors in reducing land productivity in Nepal (APP 1995; NPC 1998; World Bank 1998). It affects technology use in agriculture by increasing or decreasing the costs of inputs and the prices of products and their distribution. It is hypothesized that *access to* *transportation facilities increases the likelihood of using farm technologies.* Overall, it is hypothesized that *increased access to community services increases the likelihood of technology adoption in agriculture.*

b. Presence of Small Farmers Development Program. The Small Farmers Development Programs (SFDP) of the Agricultural Development Bank helps empower small farmers through the mechanism of group solidarity. Farmers with less than half a hectare of land can form groups of five to ten members. These groups are entitled to loans without requiring land certificates as security deposits. The SFDP also provides necessary advice to the small farmers in increasing their income through saving collections and mobilization. In the western Chitwan Valley, SFDP are implemented in two Village Development Committees, namely, Jagatpur and Meghauli. It is expected that *the presence of the Small Farmers Development Program in the community increases the likelihood of using agricultural inputs*.

c. Proximity to Urban Center. Schutjer and Van der Veen (1977) reported that constrained access to markets for inputs and outputs is one of the important barriers to technology use in agriculture. Mosher (1966) pointed out the role of markets in agricultural development. In his view, access to markets is one of the five essentials of agricultural development. Markets increase the availability of inputs and outlets for farm produce. Since markets for farm produce are mostly concentrated in the urban center, it is further hypothesized that *access to markets increases the likelihood of using farm technologies.*

3.2.4. The Conceptual Framework

Based on the theoretical explanations and empirical evidence on the adoption of modern inputs by farm households, I provide the following conceptual framework that guides this study. The basic assumptions of the conceptual framework are: (a) a household is both a production and a consumption unit, and (b) agriculture is still a dominant source of income and employment, (c) family is the major source of labor required for agricultural operations, and (d) a household tries to increase agricultural production by appropriate allocation of household resources including family labor. This scenario holds true in a rural agricultural setting including the western Chitwan Valley of Nepal, the study setting for this study.

In subsistence agriculture, a household uses traditional labor-using inputs (technologies), for example, bullocks instead of a tractor, farmyard manure instead of chemical fertilizers, and manual weeding and roughing of diseased or insect infested plants instead of using herbicides or insecticides as long as family labor is available to carry out these activities. This condition depends upon the number of working-age family members available per unit of cultivated land. If there is a shortage of family labor per unit of cultivated land, a household is motivated to use alternative labor-saving technologies in crop production. Therefore, it is argued that the availability of working-age family labor is a key for the decision to use modern labor-saving inputs in farming, net of other factors (Figure 3.1). Further, some of the farm activities are gender specific. Therefore, I also argue that the gender composition of family labor also affects technology use decision. Moreover, other demographic characteristics such as the age of the household head and the migration of family members are also expected to affect technology use in agriculture. Since other factors such as socioeconomic characteristics of a household and neighborhood characteristics described earlier also affect the use of agricultural technology, I also take into account of those factors.

For convenience, I have presented the hypothesized relationships between technology use packages and household-level demographic, socioeconomic and neighborhood characteristics in Table 3.1 below.

Figure 3.1. Conceptual Model of the Effects of Household Demographic, Socioeconomic and Neighborhood Characteristics on Agricultural Technology Use

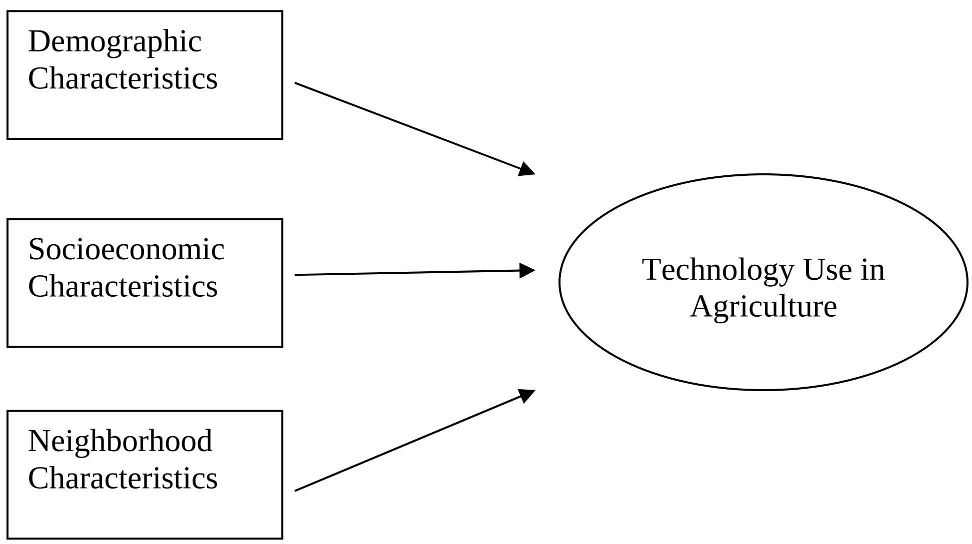


Table 3.1. Hypothesized Effects of Household Demographic, Socioeconomic and Neighborhood Characteristics on Agricultural Technology Use

Variables	Expected Direction of Relationships	
	Bio-chemical Technology	Mechanical Technology
Demographic characteristics		
Total working-age males and females per unit land	-	-
Number of working-age females per unit land	-	?
Number of working-age males per unit land	-	-
Others		
Age of the household head (years)	-	-
Migration of individual from household (yes=1)	+	+
Socioeconomic characteristics		
Quality of cultivated land (Reference = *Bari* land)		
Khet only	na	+
Khet and *bari* both	na	+
Irrigated land (percent)	+	na
Land ownership (Reference = Sharecroppers)		
Full owners	+	+
Part-owners	+	+
Fragmentation of holding (number of parcels)	-	-
Livestock ownership (yes = 1)	-	na
Education of the household head (year)	+	+
Exposure to information (own radio/TV = 1)	+	+
Ethnicity (Reference = High Caste Hindu)		
Low Caste Hindu	-	-
Newar	-	-
Hill Tibetoburmese	-	-
Terai Tibetoburmese	-	-
Neighborhood characteristics		
Number of services within a 10-minute walk	+	+
Presence of Small Farmer Group (yes = 1)	+	+
Proximity to urban center (Reference = strata 1)		
Strata 2 (between strata 1 and 3)	-	-
Strata 3 (farthest from the urban center)	-	-

na = not assessed (not included in the analysis)

3.3. Occupational Mobility[1] of Farm Households (Farm Exit)

Unlike the agriculture sector of many developed countries, Nepalese agriculture faces increasing pressure of population on limited agricultural land. While retaining family farms is a major concern for the U.S. agricultural policy (Goetz and Debertin 2001; Foltz 2003), relieving population pressure on the land is the important policy concern for Nepal (Ashby and Pachico 1987). The dynamics of population and agriculture are changing rapidly in Nepal and farm households are shifting their occupations toward non-farm activities. The second objective of this study is to explore various household-level demographic, socioeconomic and neighborhood characteristics that influence a change in household's occupation from farm to non-farm activities.

According to Moore (1966) social mobility is defined as a change in social location or position. In particular, this concept covers "changes in location (locus), relative position (status), sector, industry, or 'lateral' occupational segment (situs) or in employer (patronus)" (Feldman and Moore 1960 cited in Moore 1966:195). Borrowing from Moore's conceptualization of mobility, in this study, I define occupational mobility or farm exit as a shift in a household's occupation from farming to a non-farming one. A similar definition was used by Kimhi and Bollman (1999) in their study of farm exit in Canada and Israel. In the Chitwan Valley Study, the 2001 household survey reported that some of the households that were farming during the 1996 survey completely left their farm occupation and followed non-farm pursuits by 2001. I defined such a shift in occupation between 1996 and 2001 as occupational mobility for purposes of this study.

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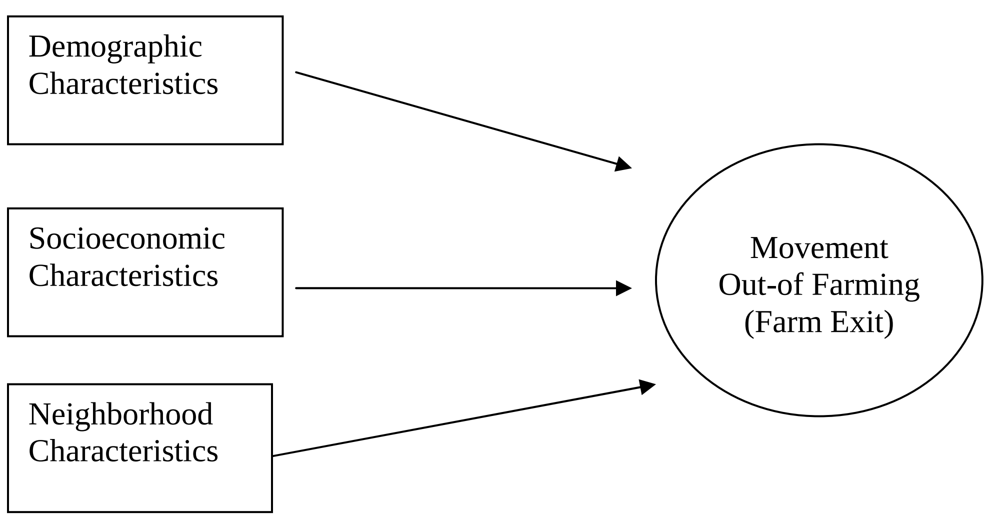
[1] In this study, the terms occupational mobility, occupational transition, occupational shift, occupational change and farm exit are used interchangeably.

3.3.1. Explanations of Occupational Mobility (Farm Exit)

At the individual level, various factors such as age, education, knowledge, and skills of individuals influence occupational mobility (Root and De Jong 1991). For example, an individual might change his or her occupation to maximize lifetime earnings utilizing his available human capital such as education, work skills and employment experience. However, it can be assumed that routes out of a farm occupation by an individual are qualitatively different from the routes out of farming by an entire family or a household. This is because all the members of a household as a single unit have to change their occupation to a different occupation. Below I consider the effects of household-level demographic, socioeconomic and neighborhood-level characteristics on farm exit.

Figure 3.2. Conceptual Model of the Effects of Household Demographic, Socioeconomic and Neighborhood Characteristics on Occupational Mobility of Farm Households



3.3.1.1. Household Demographic Characteristics

a. Size of Family Labor Pool – Working-age Men and Women. The availability of working-age members in a farm household determines the farm labor force (FAO 1986). Since size and composition of families are directly related to household production in low-income countries (Low 1986) where family labor is used in the household production process, the household pool of farm labor should have an important effect on occupation transition of a family or a household.

In developing countries, the farm sector employs a large number of unskilled individuals. A change in occupation from farming to non-farming would not be desired by a family unit with a large number of working-age unskilled members, unless the off-farm sector does not require high skills. If a household has to shift from farming to other non-farm occupations, the new occupations may not provide employment opportunities for all the members of the household. Moreover, if a farm household has more working-age members, it can be assumed that the members are more attached to the farm land and place more commitment to farming rather than leaving this occupation.

According to Stiglbauer and Weiss (2000), family members provide the necessary labor resources for continuation of the family farm business. They found a strong and positive effect of the size of family on farm succession (handing over farm to farm operator's child) and a negative effect on farm exit among Austrian farmers. The size of family may be important in farm exit decisions in developing countries where farms are operated mostly by family members. Therefore, I hypothesize that *the size of family labor pool (number of working-age males and females) is negatively associated with farm exit.*

b. Sex Composition. In developing countries, although men are also engaged in farming, women's involvement in agriculture in terms of work force and time contribution is quite significant (Boserup 1970; Patnaik and Debi 1991). Prasad and Singh (1992) noted that women play a significant role in the conservation of land, water, flora and fauna and in overall agricultural development in India. This scenario is not an exception in Nepal. For example, in Nepal, significantly more women are engaged in agriculture than men. In an estimate of the Nepal Labor Force Survey of 1998/99, of the total of 9.5 million currently employed people, about 7.2 million (76 percent) were engaged in the agriculture sector (NLFS 1999). By sex, over 85 percent of the women were currently employed in farming as compared to only two-thirds (67 percent) of the men. Further, it is reported that women invest much longer hours in farming than their male counterparts (Acharya and Bennet 1981; Jackson 1995; Kumar and Hotchkiss 1988). Nevertheless, finding a job in the non-farm sector, particularly for uneducated females is difficult and generally not desired by the family. Therefore, it is hypothesized that *a household with a larger number of working-age females is expected to be less likely to exit farming*.

c. Presence of Elderly Members. At the individual-level, it is argued that youth are more likely to change their occupations than older adults (Moore 1966; Ogena and De Jong 1999). In their study of Thailand, Ogena and De Jong (1999) observed that individuals between 15-19 years of age were significantly more likely to change occupation, followed by the individuals aged 20-29 years, in comparison to the individuals aged 30 and over. In a study of the Indian states of Kerala, Mahesh (2002) reported that younger generation people preferred to work in the non-agricultural sector and shifted their work from farm to non-farm sector, whereas the older generation preferred to continue to work on farms.

At the household-level, existing literature from developed countries suggests that age of a farm operator is expected to contribute positively to farm exit (Kimhi and Bollman 1999; Pietola et al. 2002; Glauben, Tietje and Weiss 2003; Vare and Heshmati, 2004). Similarly, Stiglbauer and Weiss (2000) reported a negative effect for young farmers and a positive effect for older farmers on farm exit in Austria. This is due to early retirement plans for farmers.

In Nepal, a government retirement plan for farmers does not exist and elderly people continue farming as long as they can. In this context, it is plausible to think that the presence of elderly persons in a household reduces the likelihood of transition from farming to non-farming activities. The reasons are: (i) older persons are already familiar with the current occupation of farming, (ii) farming is still considered a symbol of status among older generations, and (iii) they are less likely to adopt new occupations in non-farm sectors. Therefore, I expect that *presence of elderly individuals negatively affects the change in farm occupation.* Similarly, *age of the household head is negatively associated with occupation shift.*

d. Presence of Children. It is also expected that *presence of children in a household negatively affects the likelihood of changing farming to a non-farming occupation*. A farming household might have many children with the expectation of their future value as farm labor. In a farming society, access to cultivated landholding influences human fertility (Stokes 1995; Stokes and Schutjer 1984; Stokes et al. 1986; Thomas 1991). The land-labor demand hypothesis suggests that households with relatively more access to land require more labor to cultivate the land. Therefore, individuals living in a household with relatively large amounts of cultivated land demand more children. Tuladhar et al. (1982) and Gajurel (2001) also provide evidence of the land-labor demand hypothesis from Nepal. Moreover, a household with many children might be relatively more risk averse and would not desire to leave the current occupation of farming in order to have a regular source of income at least to support children unless the expected income from the new occupation is significantly much higher as compared to the income from the current occupation.

3.3.1.2. Household Socioeconomic Characteristics

a. Land Ownership. Access to and ownership of farm land is one of the important sources of income and employment in farming communities. Moreover, ownership of land is a symbol of socioeconomic status (Datta 1998; De Janvry 1981; Findley 1987), with upper-class families owning more land than lower-class families (Findley 1987). Ownership of land also provides an attachment to the place of residence (Findley 1987; Lee 1985). Goetz and Debertin (2001) and Kimhi and Bollman (1999) found a lower rate of farm exit if farmers operated their own land, in the USA and Canada, respectively. Therefore, it can be expected that *land owners are less likely to exit farm occupations than part-owners or sharecroppers*. Alternatively, it is expected that sharecropper households are more likely to shift their occupations compared to full land owners or part-owners.

b. Land Holding. Land is the basic resource for farming. It provides both employment and income to fulfill the needs of farm family members. Farmers with large land holding will be the beneficiaries of farming compared to the small land holders. Empirical evidence suggests that an increase in average farm size reduces the tendency to close down farms (Glauben, Tietje and Weiss 2003; Pietola et al. 2002; Goetz and Debertin 2001; Kimhi and Bollman 1999). According to Kimhi and Bollman (1999), a large farm size provides more income to farmers and therefore, increases their chance of survival. Therefore, it is expected that the *access to large size of cultivated land decreases the likelihood of exiting farming*.

c. Livestock Ownership. Livestock production is an integral activity of farm households in Nepal. Animals are important sources of employment and income for a farm family. Animals are kept for animal protein, draft power, and manure. Moreover, livestock and crop production are highly interlinked. Raising livestock in a household increases the bond between crop production and livestock production. Therefore, I posit that *farm families that own animals are less likely to leave farming*. Kimhi and Bollman (1999) also revealed a lower tendency of exit if farmers operate mixed livestock farms in Canada.

d. Education. Education is considered a measure of human capital. It is one of the key determinants of structural change in agriculture (Goddard et al. 1993; Stiglbauer and Weiss 2000). According to Stiglbauer and Weiss (2000), education may have two opposing effects on farm exits, however. As education increases the access to information, an educated farmer may enhance process information that may help appropriate allocation of resources thus increasing income. It may reduce a farmer’s likelihood of farm exit. On the other hand, education increases the opportunity for employment outside agriculture. As the wage or return from the agriculture sector is assumed to be more irregular than that for other off-farm sector jobs such as governmental and non-governmental sector jobs or business, it is expected that educated individuals might be more likely to leave farming. In their study of Austria, Stiglbauer and Weiss (2000) found a significant effect of education on farm exit. This finding is reasonable in the Nepalese context as more educated individuals have a tendency to leave the traditional farming and join the off-farm sector. Considering this view, I expect that if the head of the household is educated, *it is more likely that the household will exit farming*.

e. Ethnicity/Caste. As discussed elsewhere in this study, households belonging to the Terai Tibetoburmese ethnic group also known as the local indigenous people such as Tharu, Darai and Kumal are traditionally farming households as compared to the households belonging to other ethnic groups such as High Caste Hindu (for example, Brahmin and Chhetri), Low Caste Hindu (for example, Kami, Sunar, Damai and Sarki) Hill Tibetoburmese (for example, Gurung, Tamang, Magar) and Newar. Therefore, attachment of the households belonging to the Terai Tibetoburmese groups in farming occupation may be much higher than those belonging to other ethnic groups. Therefore, it is hypothesized that *households belonging to the Terai Tibetoburmese ethnic group are less likely to shift their occupation from farming to non-farming.*

f. Technology Use in Agriculture. It is argued that introduction of new farm technologies, particularly material-biased and labor-saving, is not neutral to the existing social structure and property relations (Shrestha 1990; Shrestha and Conway 1985).

They argue that the use of technologies tend to favor those who control the means of production other than labor. As a result, the economic viability of the dominant class people who own the means of production is enhanced. Others become economically more vulnerable and depend on other's resources. As the opportunities for wage employment in rural areas are scarce, one of the strategies for these people is to adapt by selling labor in the non-farm sector. It can be expected that those who do not use technologies in agriculture, cannot profit sufficiently from farming. These slow adopters or non-adopter households can no longer compete with other households that use technologies. Ultimately, these households are forced to leave agriculture (Buttel et al. 1990; Shrestha 1990). Therefore, it is expected that the households that *used technology in farming are less likely to exit farming compared to those who did not*.

3.3.1.3. Neighborhood Characteristics

Availability of community services such as banks, bus services, cooperatives, schools, health services, and employment centers might have an important influence on the occupational shift of farming households. These services are generally located in places where other off-farm opportunities and services are available. Moreover, access to transportation facilities increases the likelihood of contact with other places where off-farm employment opportunities are available. Therefore, I expect that availability of bus service nearby the household increases the chance of farm exit. In this study, availability of the above mentioned services is included with the expectation that *proximity to these services increases the likelihood of shifting from farming to non-farming occupations*.

Moreover, the Small Farmers' Development Program of the Agricultural Development Bank of Nepal is one of the successful community development programs in the country initiated to help develop small farmers' socioeconomic status. Therefore, it is expected *that the presence of community development program might decrease the likelihood of shifting occupation of farming households to non-farming activities*.

Geographic proximity of a household from the urban center might also influence a household's occupation shift from farming to a non-farming activity. In areas close to the urban center, various off-farm employment opportunities are available. Moreover, pressure on land for other non-farm economic development such as residence and business is also high compared to rural areas. Therefore, it is argued that *farming households close to urban areas may be more likely to exit farming compared to those who live in more remote rural areas.*

Presence of non-farm households in the community may have an important influence on farm exit decisions. These households may be located in areas where non-farm employment opportunities are available. Or, these non-farm households may demand special services such as banks, schools, health services, other non-farm employment opportunities and transportation facilities. These services may help develop further non-farm employment opportunities and encourage existing farm households to leave their farm occupations and join the non-farm sector. Therefore, it is expected that *living in a community with relatively greater proportion of non-farm households increases the likelihood of farm exit.*

A few neighborhoods in the study area experienced natural shock due to flooding of Narayani and Rapti rivers during 1996 and 2001. Some households lost all or part of their farm lands due to flooding. Therefore, I also examined the effect of natural shock, here flooding, experienced by farm households on farm exit. I expect that *farm households that experienced flooding are more likely to exit farming.*

The theoretically posited relationships between occupational transition and the household-level demographic, socioeconomic and neighborhood characteristics are presented in Table 3.2. In the following chapter, I describe the data sources, measurement of variables, and the data analysis techniques employed in this study.

Table 3.2. Hypothesized Effects of Demographic, Socioeconomic and Neighborhood Characteristics on Household Occupational Transition

Variables	Expected Direction of Relationship
Demographic characteristics	
Number of working-age males	-
Number of working-age females	-
Presence of elderly persons	-
Presence of children	-
Age of head of the household	-
Age of head of the household squared	?
Socioeconomic characteristics	
Land ownership (Reference = Full owners)	
Part-owners	+
Sharecroppers	+
Size of cultivated land	-
Livestock ownership (yes = 1)	-
Education of household head	+
Ethnicity (Reference = Terai Tibetoburmese)	
High Caste Hindu)	+
Low Caste Hindu	+
Newar	+
Hill Tibetoburmese	+
Technology use in agriculture	
Bio-chemical technology	-
Mechanical technology	-
Neighborhood characteristics	
Non-farm households in the neighborhood (percent)	+
Household in flooded neighborhood (yes=1)	+
Number of services within a 10-minute walk	+
Presence of Small Farmer Group (yes=1)	-
Proximity to urban center (Reference = Strata 1)	
Strata 2 (between strata 1 and 3)	-
Strata 3 (farthest from the urban center)	-

CHAPTER 4

METHODOLOGY

The purposes of this study are twofold. The first objective is to examine the effects of household-level demographic, socioeconomic and neighborhood-level characteristics on the use of labor-saving technologies such as tractors, pumpsets, farm implements, chemical fertilizers and pesticides in agriculture. The second objective is to explore household demographic, socioeconomic and neighborhood contextual factors that influence farm exit i.e., occupational shift of households from farm to non-farm activities. I used the household- and neighborhood-level data from the western Chitwan Valley of Nepal to examine these issues. In this chapter, I describe the sources of data, variables used, their measurement and the method of data analysis.

4.1. Data Sources

I used data from multiple surveys collected by the Population and Ecology Research Laboratory (PERL) located in the western Chitwan Valley of south central Nepal. These data were collected as part of the following research projects: the Chitwan Valley Family Study (CVFS) and the Population and Environment Study (PopEnv)[1]. The CVFS was the first of the research activities carried out by the PERL. The CVFS was primarily designed to examine the influence of rapidly changing social contexts on demographic processes including timing of marriage, childbearing and contraceptive use.

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[1]Both, CVFS and PopEnv research projects were supported by the National Institute of Child Health and Human Development (NICHD). W.G. Axinn, Professor of Sociology, University of Michigan is the Principal Investigator.

The focus of the Population and Environment Study was to investigate the reciprocal relationships between marriage, childbearing, migration and other demographic variables, and environmental outcomes such as changes in land use, flora diversity, and water quality and vice versa. Both of these research projects utilized the same study population from the western Chitwan Valley. The data have been collected at different levels including the household, individual, and neighborhood. I briefly discuss these data sets below.

4.1.1. Neighborhood Level Data

Neighborhoods were the lowest level sampling units chosen for the study (Barber et al. 1997). Prior to choosing samples of these neighborhoods, the study area of the western Chitwan Valley was first divided into three different strata based on the approximate distance from Narayanghat, the urban center of the Chitwan District, to select a representative sample of neighborhoods. Strata 1 included areas nearest to Narayanghat, strata 3 included areas farthest from it and strata 2 included areas in between.

The samples were selected at two stages (see Barber et al. 1997 for additional detail). In the first stage, in each stratum 10 settlements were randomly sampled based on probability proportionate to size, thus making a total of 30 settlements. These settlements were then divided into non-overlapping clusters called neighborhood or *tol* that consisted of 5-15 households. In the second stage, four neighborhoods from each settlement were chosen randomly using a systematic random sampling technique making a selection of a total of 120 neighborhoods. Since the Chitwan Valley is home to multiple ethnic groups, 12 other neighborhoods were added for ethnic representation. Finally, 39 other rural neighborhoods were included in strata 2 (19 neighborhoods) and strata 3 (20 neighborhoods) to make a final sample of 171 neighborhoods (http://perl.psc.isr.umich.edu/data.htm). Much of the data collected before 1996 were from these 171 neighborhoods. However, after 1996, the study was limited to 151 neighborhoods. Twenty neighborhoods (neighborhoods identification numbers 152 through 171) that were included as over-samples in the final sample were excluded from the survey due mainly to budget constraints.

The neighborhood information collected in 1996 included the event histories of community-level changes over time in such characteristics as presence of bus services, schools, health services, markets, dairies, cooperatives and other community services. The information included changes in time to walk (in minutes) to these services and the date when such change occurred. The information was collected from secondary data sources as well as community members using in-depth interviews and key informant surveys. The neighborhood history calendar method was employed to collect the information (see Axinn et al. 1997 for additional detail). However, in this study, I used the time-to-walk to the nearest service in question in 1996.

4.1.2. Household and Individual Level Data

I used the 1996 household census data, the 1996 baseline agriculture data (also called Time 1 data), and the 2001 agriculture data (also called Time 2 data) as described below. The survey included all the households that were present inside the aforementioned neighborhoods or clusters. The 1996 household census survey collected information on age and gender of persons living in a household and their relationships to each other. This survey included all the individuals who ate and slept in a given household during the past six months.

The 1996 baseline agriculture data, the first round of household interviews (Time 1 survey), in general, recorded information on farming activities, livestock, household assets and perceptions of changes in the environment. Of particular interest to this study, the survey recorded information on the use of various technologies in crop production such as tractors, pumpsets, chemical fertilizers and pesticides (insecticides and herbicides), farm implements, and other information such as size of cultivated holding, land ownership, livestock holdings and so on. The data were collected using a face-to-face interview technique featuring a carefully designed interviewer assisted structured schedule. The response rate was 100 percent. The 2001 agriculture survey (also called Time 2 survey) collected the same information from the households present inside the pre-defined neighborhood boundaries as collected by the 1996 household survey. I used only the farming status information from the 2001 survey for the purpose of this study.

The 1996 census data and the baseline agriculture data were collected from 1,805 households located in 171 neighborhoods. However, the 2001 agriculture data were collected from the households living in 151 neighborhoods (neighborhood identification numbers 001 – 151). In this study, I used the 1996 information to answer the first research question and 1996 and 2001 information to answer the second research question from the households present inside the 151 neighborhoods.

I used two individual-level variables, age and education of the household head in this study. These variables come from individual-level data. The data were collected in

1996 via face-to-face interviews, and include individual background characteristics, childhood context, marriage, childbearing, contraception, and individual attitudes toward various issues of family formation (Axinn, Barber and Ghimire 1997). The survey included individuals between 15 and 59 years of age and their spouses beyond this age range present in the households located in 171 neighborhoods. A total of 5,271 individuals were interviewed with a response rate of 97 percent.

4.2. Unit of Analysis

I used a farming household as the unit of analysis. A farming household is defined as a "household in which at least one member (not necessarily the head, the reference person or the main income earner) is operating a holding" as defined by the FAO (1986:144). Specifically, the survey has defined a household as farming if it is engaged in any kind of crop cultivation activities on at least 10 *dhurs* (20 *dhurs* = 1 *kattha* = 0.034 hectare) of land during the survey period. The variable was operationalized partly through responses to the yes/no question "Does your household do any farming?" The survey also asked the actual size of land under various crops during the survey year. The validity of the response on farming status was confirmed by determining whether the actual amount of land the household was cultivating during the survey period was 10 *dhur* or more. The same operational definition was used in the 2001 household survey.

4.3. Measurement of Variables

First, I describe the measurement of two dependent variables (i) technology use in agriculture, and (ii) farm exit. Then, I describe the measurement of three sets of independent variables used in this study, namely, (i) household demographic variables, (ii) household socioeconomic variables, and (iii) neighborhood characteristics.

4.3.1. Dependent Variables

Technology use in agriculture and occupational change of a household from farming to non-farming activities (farm exit) are two major dependent variables examined in this study. The operational definitions of these variables and their measurement are described below.

4.3.1.1. Technology Use in Agriculture

Technology used by farmers is considered as the use of chemical fertilizers, pesticides, tractors, farm implements, and pumpsets in producing various crops. For the purpose of this study and as discussed elsewhere, I have grouped these technological inputs into two packages: (i) Package I – bio-chemical technology, which includes the uses of chemical fertilizers and pesticides, and (ii) Package II – mechanical technology, which includes the uses of tractors, pumpsets, and other improved farm implements. These variables were measured in 1996.

a. Package I – Bio-chemical Technology

Use of Chemical Fertilizers and Pesticides/Herbicides. The survey collected information on the use of chemical fertilizers and pesticides/herbicides by asking whether a household used any chemical fertilizers and pesticides/herbicides in the past three years. The question was: “Did you use chemical fertilizer in the past three years?” A similar question was asked for pesticide/herbicide use. The answers were recorded as "1" if a household did so and "0" otherwise.

An index was created to measure the degree of use of bio-chemical technology. These dichotomously coded variables were added together, which grouped farmers into three categories: (a) a farmer used none of them (coded 0), (b) a farmer used any one of them (coded 1), and (c) a farmer used both of them (coded 2). This variable has been used as an explanatory variable of farm exit and measured as a dichotomy, a household used any bio-chemical input (coded 1) versus did not use any (coded 0).

b. Package II – Mechanical Technology

(i) Tractors Use. In the Chitwan Valley, tractors are commonly used by farmers for land preparation, specifically for the first tillage operation. Tractors are also used for other purposes like threshing and transportation of grain and straw. In this study, tractor use was measured with a survey item that asked "Did your household use a tractor to plough the land for planting ….. crop?" The variable is coded "1" if that household used a tractor in plowing the land and "0" otherwise.

(ii) Use of Pumpsets and Farm Implements. Canal water is commonly used to irrigate crop fields during the monsoon season in the Valley. However, where crop fields are inaccessible to canals, a pumpset is used to lift water from the canals or wells to irrigate the fields. In the Valley, irrigation water is not distributed through canals during the winter season. Therefore, the use of a pumpset increases when canals are dry. It is assumed that a household that owns a pumpset uses them in farming. Ownership of a pumpset, in this study, is used to measure the access to and use of well-controlled irrigation even during the dry season. In the survey, information on the ownership of a pumpset by farm households was obtained by asking "Do you have a pumpset for irrigation?" The variable was coded "1" if the answer is yes and "0" otherwise.

Similarly, ownership of other farm implements such as a thresher, chaff cutter, sprayer, corn sheller, or other implements is also considered as an indicator of improved technology use on the farm. To measure this variable, the survey asked "Does your household have a thresher, chaff cutter, sprayer, corn sheller, or any other kind of farm tools?" The response was recorded as "1" if a household owns any of these implements and "0" otherwise.

As in bio-chemical technology use, I constructed an index to measure the degree of use of mechanical inputs on the farm. The dichotomously coded responses of three mechanical inputs were added together, which grouped farmers into four categories: (a) a farmer used none of them (coded 0), (b) a farmer used any one of them (coded 1), (c) a farmer used any two of them (coded 2), and (d) a farmer used all three of them (coded 3). Since there were only a few cases (n = 19; 1.6 percent) of farmers who fell into the fourth category (used all three of them), I regrouped these farmers into three categories as (a) a farmer used none of them (coded 0), (b) a farmer used any one of them (coded 1), and (c) a farmer used any two or more of them (coded 2). This variable is also used as an explanatory variable of farm exit and measured as a dichotomy, a household used any mechanical input (coded 1) versus did not use any (coded 0).

4.3.1.2. Occupational Mobility of Farm Households

The next dependent variable is the occupational mobility of farm households. In the Chitwan Valley Study, the 2001 household survey reported that some of the households that were farming during the 1996 survey left their occupation and followed non-farm activities by 2001. I defined such a shift in occupation between 1996 and 2001 as occupational mobility (farm exit) for purposes of this study.

The 1996 household survey confirms the farming or non-farming status of a household by asking, "Does your household do any farming?" Similarly, the 2001 household survey also asked this same question to the household that was surveyed in 1996. This survey also followed the same definition of farming household, cultivating 10 *dhur* (0.5 *kattha*) or more land as described elsewhere in this chapter to identify a household's farming status and followed the same procedure to collect the information.

Every household had been given a unique household identification number in 1996 that was retained and assigned to the household in 2001. Therefore, it is easy to identify and compare the status of a household by using this unique identifier in different surveys. Using this unique identifier, a household's farming status recorded in 1996 was compared to the farming status of the same household in 2001. For example, if a household was farming in 1996 and was not farming in 2001, this household is considered as the one whose occupation has changed. Thus, occupational mobility is measured as a dichotomous variable and is coded "1" if a farming household reported a shift to a non-farming occupation and "0" otherwise i.e., continued farming between 1996 and 2001.

4.3.2. Explanatory Variables

I describe below the operationalization of variables used in predicting two dependent variables – use of bio-chemical and mechanical technologies, and occupational mobility of farm households toward non-farm activities. Since most variables used for explaining both of the dependent variables are similar (see Tables 3.1 and 3.2 in Chapter 3), I have described their measurements under the same section.

4.3.2.1. Household Demographic Characteristics

The 1996 household census reported the household-level demographic characteristics such as the number of individuals who were living in a household during the survey year, and for each their age and sex. Based on the information, the following variables were used.

a. Presence of Working-age Males and Females. The number of the working-age members in a household is measured as the total number of men and women 15-64 years of age living in a household at the time of survey in 1996. These variables are used as is in the analysis of farm exit, and to calculate a ratio of the number of working-age individuals (males and females) per unit of cultivated land in explaining the use of technologies in crop production.

The potential labor force in farming is determined by the availability of working-age individuals in a household (FAO 1986). Therefore, I used family labor availability per unit of cultivated land as an important independent variable of technology use. I defined labor availability in a household as the number of working-age men and women per unit of total cultivated land (here, hectare) in a given household. A similar measure of per-hectare family labor potential was used by Rauniyar and Goode (1996) in their study of Swaziland.

The total cultivated land is the total of *bari* and *khet* land cultivated by a farm household during the survey year. In the Chitwan Valley, two types of farm land are available – *bari* and *khet*. The *bari* is upland, usually un-irrigated, and generally not suitable for rice cultivation. The *khet* is low lying area and can be irrigated during monsoon season and is good for rice planting. The *khet* is considered good quality land in terms of production and price compared to the *bari*.

The 1996 household survey first confirmed whether a household has farmed any *bari* or *khet* land. A separate question was asked "Do you farm any *bari* land where you cannot grow rice?" and for *khet* "Do you farm any *khet* land?" The response was recorded as "yes" or "no." Upon confirmation, the next question asked the size of *bari* and *khet* land. The amount of land was recorded in the local unit, *bigha* (1 hectare = 1.5 *bigha*) and *kattha* (1 hectare = 30 *kattha;* 1 *bigha* = 20 *kattha*). Then, the amounts of both *khet* and *bari* land in *kattha* were added to find the total cultivated size of holding.

Family labor availability per unit of total cultivated land was calculated by dividing the total numbers of working-age males and females of 15-64 year of age (for total labor force), number of working-age females, and number of working-age males present in a household at the time of survey by the total land size cultivated by a household measured in *kattha* during the survey period in 1996. It provided the number of working-age family members per *kattha* of cultivated land, which was multiplied by 30 to obtain the number of working-age family members per hectare of cultivated land. Thus, I obtained three variables: (i) number of working-age males and females (total labor) per hectare, (ii) number of working-age females per hectare, and (iii) number of working-age males per hectare of cultivated land. I also used the squared-term of labor availability (for total, male and female) to examine if any curvilinear effect of labor availability on modern inputs use exists.

b. Presence of Elderly Members. Presence of elderly individuals in a household is measured as the number of individuals over the age of 64 years.

c. Presence of Children. This variable is measured as the total number of children below 15 years of age present in a household and is used in explaining occupation change of a farm household. The numbers of children are grouped as (i) below 6 years of age, and (ii) 6 to 14 years. The assumption is that children 6 years and above can help their parents and adults in certain household tasks as well as in farm work, whereas children below 6 years of age demand time from parents or adults for their care. Similar age categories were used by Kumar and Hotchkiss (1988) in their study of time allocation patterns of men, women and children in Nepal.

d. Age of the Household Head. The survey data used in this study do not identify a household head. Usually, older males are considered as the head of a household in a patriarchal society like Nepal. Therefore, I considered the oldest male present in a household as the head. If there was no male in a household, I considered the oldest female as the head. The age of the household head is measured as a continuous variable in years at the time of survey.

e. Migration of Family Member(s). The 1996 survey considered a migrant individual as an individual who is staying away from his or her home for most of the time in the past six months at the time of survey in 1996. To measure this variable, each household was first asked “Are there any household members who stay away from home most of the time in the past six months?” The survey further asked the reasons for the move, “Is (name) away because of work, study, or for some other reason?” In the analysis, this variable is dichotomously coded as “1” if any member is away from home for work reason, and “0” otherwise.

4.3.2.2. Household Socioeconomic Characteristics

a. Socioeconomic Status - Land Ownership and Land Holding. In this study, land ownership is considered as a measure of household socioeconomic status. Land owner farmers are considered to have higher socioeconomic status compared to part-owners and sharecroppers.

Land ownership is measured as full owner-cultivators, owner plus sharecroppers (part-owners), and sharecroppers. The 1996 household survey revealed information about the ownership of *bari* and *khet* land separately by asking “Does your household own the land, is it sharecropped, is it mortgaged, is it on contract to you, are you the tenant of the land or are there some other arrangements?” Based on the information provided to each category, I recoded the responses and categorized them as (i) full owners, (ii) owner plus sharecroppers (part-owners), and (iii) sharecroppers.

Land holding is considered one of the explanatory variables of occupation change. I used the total cultivated size of holding in *kattha,* the measurement of which is described elsewhere in this section.

b. Quality of Land. To examine the effect of the quality of cultivated land on technology use, I categorized households into three groups, (i) those that cultivate only *khet* land, (ii) that cultivate both *khet* and *bari* land, and (iii) that cultivate only *bari* land. This information has been used in the analysis of mechanical technology use. In the case of bio-chemical technology use, I used the percent of irrigated land as a measure of quality of land owned by a household to explain the use of bio-chemical inputs. The availability of irrigated land is important for the use of bio-chemical technologies, while the availability of *bari* and *khet* land is important for the use of mechanical technology. This is because the households may use chemical fertilizers in irrigated fields rather than in unirrigated fields. But the use of a pumpset or a tractor is associated with the type of land. For instance, a household will try to use a pumpset to irrigate *bari* land, which is usually unirrigated and *khet* land, which is usually irrigated but is difficult to plow by bullocks.

The survey has collected information on the amount of *bari* and *khet* land that can be irrigated by asking two separate questions for *bari* and *khet* land, "What is the area of your (*bari* land/*khet* land) that can be irrigated?" The amount is recorded in *bigha* and *kattha*. The total amount of *bari* and *khet* land is added to get the total irrigated land. Then, the total irrigated land thus obtained was divided by the total land cultivated and multiplied by 100 to find the percentage of irrigated land in a household.

c. Land Fragmentation. Fragmentation of land holding, that is, the distribution of land into several parcels, is another factor affecting the use of technologies in agriculture. Land fragmentation, on the one hand, reduces the size of cultivated land; on the other hand, it separates land parcels into different pieces thus making it uneconomical to use technologies such as a tractor for plowing and a pumpset for irrigation. In the household survey, information on land fragmentation was obtained by asking a question

"On how many sites or parcels of farmland does your household farm?" The response was recorded as number of parcels and used in the analysis.

d. Livestock Ownership. In Nepalese agriculture, farming and livestock keeping are closely integrated. One of the purposes of keeping livestock is for farmyard manure. Application of farmyard manure or compost is a common practice in Nepal as well as in the Valley. Since buying and selling of manure is virtually absent, a household with animals is assumed to use manure rather than chemical fertilizers in crop fields. In occupational mobility, livestock keeping provides both income and employment to the household and is closely linked with crop cultivation. Therefore, it is expected that occupation change and livestock keeping are associated. The survey asked the question "Does your household raise livestock?" The answer is dichotomously recorded as "yes=1" or "0" otherwise.

e. Education of the Household Head. At the household level, it is unclear whose education counts when it comes to technology adoption. However, in general, the education level of the household head is used in analyses of this sort (for example, Godoy et al. 1998; Pitt and Sumodinningrat 1991) with the assumption that household heads make most decisions. Others, however, have used average number of years of schooling per household member (for example, Rauniyar and Goode 1996).

As mentioned earlier, I have considered the education level of the oldest male member in a household, who has been considered as the head of this household in this study. If there is no male in a household, I have considered the education level of the oldest female in that household. The survey measured education as a continuous variable, in number of years of schooling.

f. Access to Information. Access to information increases the likelihood of adopting a new technology by reducing uncertainty. However, there are problems in measuring the extent of the exposure to information sources as proxies might not appropriately measure the exposure variable (Feder et al. 1985). They report some commonly used proxy measures of the exposure as whether a farmer was visited by an extension agent or whether a farmer has attended various demonstrations. Other measures reported are farmers' exposure to mass media (for example, newspaper, radio), leaflets, literacy, level of education, and period of time spent outside of the village.

In the absence of other measures, in this study, the access to information is measured in terms of the availability of a radio and/ or a television in a household. Radio Nepal, the state owned radio program, is an important source of agricultural information in the country. It regularly broadcasts information related to agriculture through its "Agricultural Program." Similarly, Nepal Television, the state-owned television network, and other television stations like Dur Darshan (Indian Television) also provide information about agricultural technology use. This variable is measured as "1" if a household owns radio and/ or television and "0" otherwise.

g. Ethnicity. Technology use in agriculture and occupational mobility are expected to vary by ethnicity. As is often done (for example, Axinn and Barber 2001; Gajurel 2001), the ethnicity of each household is grouped into High Caste Hindu (for example, Brahmin and Chhetri), Low Caste Hindu (for example, Kami, Sunar, Damai, Sarki), Newar, Hill Tibetoburmese (for example, Gurung, Magar, Tamang), and local indigenous Terai or Terai Tibetoburmese (for example, Tharu, Kumal and Darai) groups.

4.3.2.3. Neighborhood Characteristics

Neighborhood contexts such as the access to banks, cooperatives, the Small Farmer Development Program, markets, and transportation facilities may influence the use of technology in agriculture. In addition to these services, availability of institutions and services such as schools, health services and employment opportunities might have an important effect on occupational shifts of households from farming to non-farm activities. Therefore, I used the availability of the following neighborhood contexts as factors affecting the use of technology in agriculture as well as occupational change of a farm household. All the variables were measured in 1996.

a. Access to Community Services. In the Chitwan Valley, the Agricultural Development Bank and other banks such as the Nepal Commercial Bank (Nepal Vanijya Bank) and Nepal Bank Limited provide credit to farmers for agricultural purposes. Similarly, access to agricultural cooperatives is also an important source of chemical fertilizers and pesticides. Access to a road increases the access to markets for inputs as well as outputs. It affects technology use in agriculture by decreasing the costs of inputs and increasing the accessibility to product markets. Access to transportation also increases access to other off-farm employment opportunities, thus increasing the likelihood of shifts out of farming. Other services included are the access to schools, health services, and employment opportunities. The employment opportunities include factories, schools, government offices, hotels, and banks that can be walked from the neighborhood. In the survey, all these variables are measured as the time to walk in minutes to the nearest service from the neighborhood.

Since most of these services are likely to be concentrated in one place, there could be a high correlation between access to banks, cooperatives, bus services, schools, health services, and employment opportunities. Therefore, an index was constructed to measure the degree of accessibility to these services. To create an index, first, the time to walk to the given service was recoded as “less than or equal to 10 minutes” coded as “1” and “more than 10 minutes” coded as “0” as used by Gajurel (2001). Then, these re-coded variables were added together to obtain the number of services within a 10-minute walk. This is the measure of the degree of accessibility to various services.

Two separate indexes of services were created to be used in the analysis of technology use and occupational change of farming household. For technology use, the access to banks, cooperatives, and bus services were considered. The index ranges from 0 to 3, 0 implying no access to services within a 10-minute walk and 3 implying access to all these services within a 10-minute walk. To examine the effect of the access to services on occupational change of farm household, the access to banks, bus services, cooperatives, schools, health services, and employment opportunities were considered. The index ranges from 0 to 6. These indexes were used as continuous variables in the analysis.

b. Presence of Small Farmer Development Program. Small Farmer Development Program (SFDP) of the Agricultural Development Bank provides necessary inputs, credit, and advice to small farmers in two Village Development Committees, namely, Jagatpur and Meghauli in the study area. As the presence of SFDP in the community or neighborhood might increase the likelihood of using agricultural inputs, the presence of a member in the neighborhood or community has been used as another independent variable in the analysis. Similarly, the SFDP has also a community development component in its program which might affect occupational shift of a farm household. The presence of the small farmer development program in the neighborhood is coded “1” if present and “0” if not.

c. Access to Urban Center. Narayanghat is the urban center and the headquarters of the Chitwan District. This is the main outlet for agricultural produce in the Valley. Moreover, this is the place where large numbers of private agro-veterinary services are established. These agro-vets sell pesticides and other inputs such as high yielding variety of seeds to the farmers. These are also the important sources of information for the farmers about new technologies. Moreover, off-farm opportunities are also available in the urban center and its vicinity. Therefore, in this study, I have controlled the effect of strata – the relative location of a household from the main urban center of Narayanghat. The study area of western Chitwan Valley is divided into three different strata based on the approximate distance from Narayanghat. Dummy variables are used to identify those residing in strata 2 and 3. Stratum 1, the area closest to the urban center is used as the reference group in the analysis.

d. Percent of Non-farm Households in the Communities. Presence of non-farm households in the community has been considered as an important factor contributing to farm exit and is measured in percentage. This is estimated as the number of non-farm households divided by total number of households in the community and then multiplied by 100.

e. Experience of Natural Shock. A few neighborhoods in the study area experienced natural shock due to flooding of Narayani and Rapti rivers during 1996 and

2001. It is expected that such a natural shock may encourage farm exit decisions. This variable is measured as whether the neighborhood experienced any shock due to flooding and dichotomously coded "1" if experienced any shock versus "0" otherwise.

4.4. Techniques of Data Analysis

For data analysis, I used univariate, bivariate and multivariate statistical tools. First, I described the status of farming, technology use in farming, occupational shifts of farm households and other associated factors using descriptive statistical tools such as mean, standard deviation, range and percent. Then, I examined bivariate associations between variables by using Pearson's correlation and one-way ANOVA wherever appropriate.

I also used the Pearson's correlation to diagnose potential multicollinearity problems in the data. Multicollinearity arises when two or more independent variables are strongly correlated (Menard 1995; Schroeder et al. 1986; Walsh 1990). This affects the standard errors of the regression coefficients and therefore, the tests of their statistical significance. A correlation of 0.70 or higher between two independent variables is considered as alarming (Walsh 1990). I used this criterion as a benchmark to examine the multicollinearity problem in the data. It is suggested to look for "high" correlation coefficients between the independent variables included in the analysis as a way to detect multicollinearity and drop one of them if it exists (Schroeder et al. 1986).

Collinearity diagnostics, the tolerance statistics, provided in the linear regression analysis of the SPSS program were also used to identify possible collinearity problems. The tolerance statistics reflect the variance in each independent variable not explained by all other independent variables (Menard 1995; Norusis 1990). According to Menard (1995), a tolerance statistics "less than 0.20 is the cause for concern and a tolerance of less than 0.10 almost certainly indicates a serious collinearity problem" (p. 66). Although the tolerance statistics are not available in SPSS Logistic regression procedure, it is available in linear regression procedure. Menard (1995) suggests using the linear regression analysis with the same dependent and independent variables used in the logistic regression to obtain it and test the collinearity.

I used both binary and multinomial logistic regression techniques depending upon the measurement of the dependent variables. The dependent variable occupation change is a dichotomy as households either did (coded 1) or did not (coded 0) exit farming. Accordingly, I used the binary logistic regression analysis technique to examine the net effects of various explanatory variables on farm exit. The binary logistic regression equation used is as follows (Menard 1995; Pampel 2000; Agresti 2002; Lottes, DeMaris and Adler 1996; Peng et al. 2002; Hosmer and Lemeshow 2000):

$$\text{Logit}(Y) = \ln [P_i/1- P_i] = \alpha + \beta_{iXi} + \beta_{iiXii} + \ldots + \beta_{nXn} + \varepsilon \qquad \text{[Equation 1]}$$

Where, P_i is the probability of experiencing an event and 1- P_i is the probability of not experiencing an event. The ratio of P_i to 1- P_i is the odds of experiencing the event. The logit (Y) is the natural logarithm of the odds, α is the intercept, βs are the regression coefficients associated with the explanatory variables, xs are the explanatory variables used in the analysis, and ε is an error term, the effect of all other factors not included in the model.

The other two dependent variables, the uses of bio-chemical (chemical fertilizers and pesticides), and mechanical (tractors, pumpsets, and farm implements) technologies are measured as ordinal categories. The bio-chemical technology is measured as (a) a farmer used none of them (coded 0), (b) a farmer used any one of them (coded 1), and (c) a farmer used both of them (coded 3). Similarly, mechanical technology is measured as (a) a farmer used none of them (coded 0), (b) a farmer used any one of them (coded 1), and (c) a farmer used any two or more of them (coded 3). Since these outcome variables are ordinal in nature, first, I used ordinal (or ordered) logistic regression as a multivariate tool. I used the SPSS Ordinal Regression procedure, or PLUM (Polytomous Universal Model), which utilizes the cumulative logit model (also called the proportional odds model) (Ananth and Kleinbaum 1997)) to estimate the "odds of being at or below a particular category" (O'Connel 2006). The equation for the cumulative odds model (proportional odds model) is as follows (O'Connel 2006):

$$\ln(Y'j) = \ln\left(\frac{\pi j}{1 - \pi j(x)}\right) = \alpha_j + (\beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n) \qquad \text{[Equation 2]}$$

Where, Y' is the log of the odds, $\pi j(x)$ represents the probability that a response falls in a category less than or equal to the jth category (j = 1, 2, …k-1), α_j are the intercepts for j categories of dependent variables, βs are the regression coefficients, and xs are the independent variables.

In ordinal logistic regression, each logit has k-1 intercepts (α-values or threshold values), where k is the number of categories in the dependent variable. But there is only one beta (slope) coefficient (β-coefficient) across categories. The threshold values (αs) are similar to the intercept in a linear regression, but are not of much interest (Norusis 2004). While these threshold values are used to estimate the cumulative odds, β-coefficients are the cumulative logits, the log odds of being at or below a particular category (O'Connel 2006).

A proportional or parallel odds assumption is made about the data when fitting the ordinal regression models (O'Connel 2006; Ananth and Kleinbaum 1997; Cohen et al. 2003; Norusis 2004). This assumption is tested to examine if the effects of the independent variables are the same for different logit functions. This test is also called "The Test of Parallel Lines" in SPSS or the "Score Test" in SAS. In the test of parallel lines (output in SPSS), the row labeled "Null Hypothesis" provides the -2 Log Likelihood which assumes the lines as parallel and the row labeled "General" provides the -2 Log Likelihood for the model with separate lines. The Chi-square value is the difference between the two -2 Log Likelihood values. If the Chi-square value is small and the difference between these two values is not statistically significant, one cannot reject the null hypothesis that the lines are parallel. In this case, the use of ordinal logit model is justified. This implies that the assumption of proportional odds or parallel lines holds true, and there is only one slope coefficient for different ordinal categories of the dependent variable. However, if the difference is statistically significant, the use of the ordinal logit model is not appropriate for the data. This implies that the explanatory variables have a differential effect on the odds for each category (O'Connel 2006) or the relationships between the independent variables and logits are different for all logits (Norusis 2004).

When I used the ordinal logistic regression, the test of parallel lines turned out to be statistically significant in all the models for both technological packages. This provided me sufficient justification to reject the assumption of parallel lines and suggested that the regression coefficients are different for each category of the dependent variable. In other words, this result implied that at least one of the explanatory variables may have a differential effect across the outcome levels (O'Connel 2006). In this situation, Norusis (2004) suggested considering an alternative analysis technique particularly multinomial regression, which I used in this study and is discussed below.

Multinomial logistic regression (also called the polytochomous or polytomous logistic regression) is used to estimate the dependent variable that has more than two nominal categories or possible values (Bull and Donner 1987; Lee et al. 2002; Menard 1995; Hosmer and Lemeshow 2000; Liao 1994). According to Hosmer and Lemeshow (2000), the multinomial logit equation is:

$$g_1(x) = \ln\left[\frac{\Pr(y=j)/x}{\Pr(y=J)/x}\right] = \alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots\ldots + \beta_n x_n \qquad \text{[Equation 3]}$$

Where, $g_1(x)$ is the logit function, Pr(y=j) is the probability of the ith category of the dependent variable, α is the intercept, βs are the regression (slope) coefficients, and xs are the covariates. This equation is generalized from binary logistic regression. This equation is used to compare other outcome categories with the reference group. In both binary (Equation 1) and multinomial logistic regression (Equation 3), when βs are 0, the dependent variable is independent of the explanatory variable x.

For easy and clear interpretation, results are presented as odds ratios. While an odds ratio is the ratio of two odds, odds are the ratios of two probabilities (Lottes et al. 1996; Powers and Xie 2000). According to Liao (1994:16), the odds ratios are "the odds of having an event occurring versus not occurring, per unit change in an explanatory variable, other things being equal." The value of odds ranges from 0 to infinity.

For continuous independent variable "an odds ratio greater than 1 indicates that the odds of being ….. increases when the independent variable increases; and an odds ratio of less than 1 indicates that the odds of being …. decreases when the independent variable increases" (Menard 1995:49). In other words, "an odds ratio greater than 1.0 indicates an increased likelihood of the event occurring, while an odds ratio less than 1.0 indicates a decreased likelihood of the event occurring" (Morgan and Teachman 1988:930). For categorical independent variables, "an odds ratio greater than 1 indicates an increased chance of an event occurring versus not, and an odds ratio less than 1 indicates a decreased chance of an event occurring versus not occurring" (Liao 1994:15). The odds ratios for multinomial logistic regression are also interpreted in a similar way described above for the binary outcome variable (Hosmer and Lemeshow 2000).

Odds ratios can also be expressed as percentage increase or decrease in dependent variable due to a one-unit change in the independent variable as (Pampel 2000):

$$\text{Percent change in odds} = (e^{b}-1)*100 \text{ or, } (\text{odds ratio} -1)*100 \qquad \text{[Equation 4]}$$

Results are also presented as unstandardized logistic regression coefficients. The unstandardized logistic regression coefficients are interpreted as the increase or decrease in the logged odds of the dependent variable due to a one-unit change in the independent variable (Pampel 2000; Menard 1995). For dummy variables, the logged odds compares to the reference category. For example, being in a certain category increases or decreases the logged odds compared to the reference category. Wald chi-square is used to assess the statistical significance of parameter estimates. I now turn to the analysis itself.

CHAPTER 5

TECHNOLOGY USE IN AGRICULTURE

5.1. Introduction

The purpose of this chapter is to examine the effects of household-level demographic, socioeconomic and neighborhood-level factors on the uses of bio-chemical and mechanical technologies in agriculture. As discussed elsewhere in the previous chapters, agricultural production per unit of cultivated land in Nepal is very low and has remained almost stagnant for the last several decades (APP 1995; Chitrakar 1990; ANZDEC Limited 2002). Despite the Nepalese government's efforts to increase food production commensurate with the high population growth rate, growth of food production has not matched the growth of population (World Bank 1998). It has been realized that among other factors, no or low use of modern farm technologies such as high yielding variety seeds, fertilizers, irrigation, and improved farm tools/equipment is one of the important reasons for low agricultural productivity and food production (APP 1995).

Although controversies exist about the use of green revolution technologies worldwide (see for example, Cleaver 1972; Griffin 1974; Jacoby 1972) as discussed in Chapter 2, the Agricultural Perspective Plan (APP) of Nepal, a 20-year agricultural development plan has been implemented in the country. The APP is inspired by John Mellor's (1976) belief of benefiting rural poor by encouraging them to use green revolution technologies. The belief is that the large multiplier effects of agricultural growth arising due to the use green revolution technologies will help increase the income-earning opportunities of poor people. The APP is committed to consider the negative impacts of green revolution technologies by focusing on Integrated Pest Management (IPM), which combines chemical, biological, mechanical, and cultural methods of controlling pests taking into account existing socioeconomic conditions of farmers and their resource base (APP 1995).

In an agricultural society such as Nepal, a household uses family resources in farming as far as possible including family labor. In the subsistence agriculture of Nepal, although labor can be hired or exchanged for certain agricultural operations such as rice transplantation and harvesting (Bhandari et al. 1996-97), family labor is widely used in land preparation, manure application, irrigation, weeding, and thinning out diseased or insect-infested plants. However, some farmers also use modern inputs such as chemical fertilizers, pesticides, tractors, pumpsets, and other improved farm implements to augment farm production. This raises a question: why do some farmers use modern inputs and others do not?

Studies report that no or low use of these modern inputs is primarily due to an inadequate and untimely supply of these materials (APP 1995; Chapagain 2001; ANZDEC Limited 2002; NPC 2003; Pant and Jain 1969). Other constraints are quality of inputs, cash flow problems, difficult topography and lack of knowledge about modern inputs (ANZDEC Limited 2002). Therefore, the government has prioritized the procurement and distribution of these inputs focusing primarily on economic factors such as price, income, and transportation costs. For example, for the last several years, the government provided input prices as well as transportation subsidies to the farmers, which the government eliminated in 1997 (Ministry of Agriculture and Cooperatives

2002). Similarly, the government has established agricultural development programs all over the country, particularly focusing on small farmers with the realization that large farmers have benefited from the past policies. Despite these efforts, input use is still very low in the country (APP 1995; ANZDEC Limited 2002), and agricultural production per unit of cultivated land is one of the lowest in the South Asia region.

It is widely reported that bio-chemical and mechanical technologies used in agriculture are labor-saving in nature (for example, Boserup 1965; Rauniyar and Goode 1996). Therefore, the availability of labor influences decisions to adopt technology in agriculture (Feder et al. 1985; Karablieh and Salem 2003; Schutjer and Van der Veen 1977). However, the importance of labor input in Nepalese agriculture has never received attention in agricultural development efforts in Nepal including the APP (ANZDEC Limited 2002). Since family labor is widely used in Nepalese agriculture, and the use of modern inputs replaces family labor, I believe that the availability of working-age family members is important in explaining no or low use of modern inputs. Therefore, I argue that, other things remaining the same, the number of working-age family members per unit of cultivated land reduces the likelihood of using modern technologies in crop production.

As discussed elsewhere in Chapter 3, some of the agricultural operations are gender specific (Acharya and Bennet 1981; Agarwal 1992; Bhandari et al. 1996; Boserup 1971, 1990; Prasad and Singh 1992; Sachs 1996; Rani and Malaviya 1992; Singh et al. 1992). Therefore, I also expect that the presence of working-age men and women may have important implications in the decision to use modern labor-saving technologies.

Moreover, the role of the household head is quite important in farming communities in making crucial decisions. Similarly, as discussed elsewhere in Chapter 3, migration of individuals may have important implications on labor availability or income prospects of the household. Therefore, I also include these two demographic factors in this analysis. While older farmers may be less likely to use new farm technologies, households with members away for migration may be more likely to use them.

Household socioeconomic characteristics such as land ownership and quality of farm land, land fragmentation, education, exposure to information, and ethnicity may also influence the decision to adopt modern inputs. Similarly, the access to services such as banks and cooperatives, and the access to markets may have an important effect on the adoption of modern inputs. Therefore, I also examine the effects of these household socioeconomic and neighborhood characteristics on technology use. The study adds to the previous literature by providing important information, particularly by examining the effects of family labor availability, their gender composition, age of the household head, and migration of individuals from the household on the use of modern technologies in crop production. At the same time, this study also provides important information regarding the effect of socioeconomic and neighborhood factors on technology use in the Nepalese context.

As discussed in Chapter 3, I considered two packages of technology used in crop production by the farm households. These packages are bio-chemical technology and mechanical technology. The bio-chemical technology package includes the use of chemical fertilizers and pesticides, whereas the mechanical technology package includes the use of tractors, pumpsets, and other improved farm implements.

5.2. Analytic Strategy

A household living within 151 CVFS neighborhoods and currently farming during the 1996 household survey is used as the unit of analysis in this study. Of the total 1,583 households, over 80 percent of them (n=1,269) were farming in 1996. Since age and education of the household head considered in this study come from individual-level data that are collected from the individuals between 15-59 years of age and their spouses, a total of 41 households (3.2 percent) with individuals outside this age range and another 3 households with missing information on some of the variables were excluded from the analysis. This yielded a final sample of 1,225 households. Since about 3.8 percent of households (n=46) had over 30 total working-age family labor per hectare of cultivated land (over 1 person per *kattha*), I recoded these households as having 30 family labor per hectare to minimize the effects of outlier values in the analysis.

I used the univariate statistical tools such as the mean, standard deviation, minimum, and maximum to summarize the variables. I also used the bivariate statistical tools such as the one-way ANOVA for mean comparison and Pearson's correlation to examine the associations between the interest variables and to identify the multi-collinearity problems. Then, as the dependent variables bio-chemical technology and mechanical technology are measured in categories, I used multinomial logistic regression to examine the independent effects of interest variables on the use of these technologies.

In the multivariate analysis, first, I examined the effects of the presence of total working-age family (male plus female) members per unit of cultivated land, other demographic and socioeconomic factors and neighborhood characteristics on the use of farm technologies. Then, I examined the effects of men and women separately by disaggregating the labor pool by sex to see whether it has a differential effect on technology use. The disaggregation is important because the roles of women in farming in Nepalese agriculture are crucial but were not emphasized in the past (APP 1995).

5.3. Results and Discussion

5.3.1. Univariate Analysis

The descriptive statistics of variables used in the analysis are presented in Table 5.1. Of the total 1,225 farm households, 83 percent used chemical fertilizers and 23 percent used pesticides/herbicides in crop production. While 63 percent of the total farm households used only one bio-chemical input, 21 percent of households used both of them. Similarly, 77 percent of the households used a tractor for plowing of crop fields, 14 percent owned improved farm implements, and four percent owned a pumpset. Putting these together, 14 percent of the farmers were found to use any two or more mechanical inputs, whereas 66 percent of them used only one. Although large proportions of the households used both of these bio-chemical and mechanical modern inputs, there are households that did not use these inputs in crop production during the survey year.

A household, on average, consisted of about six (mean = 5.76) persons. This average family size is slightly larger than the national average of 5.56 reported in 1991 and 5.38 in 2001. However, it is close to the household size of 5.79 reported for the central Terai in 2001. A household had about 8 working-age men and women per hectare of cultivated land. It suggests that about 8 individuals between 15-64 years of age are available to work on a hectare of land. When disaggregated by gender, the average number of working-age males and females per hectare of cultivated land was about the same, 3.91 and 3.99 persons per hectare, respectively. A typical farm household head was about 42 year old. One in every four households had at least one individual away from home for work reasons, defined as migration of individual in this study (as discussed in Bhandari 2004).

The average size of cultivated land per farm household was less than a hectare (25.04 *kattha* = 0.83 hectare; 30 *kattha* =1 hectare) with a minimum of 1 *kattha* (0.03 hectares) and a maximum of 200 *kattha* (6.67 hectares). This average size of land is slightly lower than the national average of 0.96 hectares reported in 1992 (Sijapati 1998). Using the definition used by Shrestha (1990)[1], a typical farm household falls under the subsistence category with less than 1 hectare of land. And over 66 percent of the households had less than one hectare of land. Moreover, the average number of parcels (also called land fragmentation) per household was 2.12 parcels per household implying that a household's land (i.e., 25.04 *kattha*) was scattered to at least three different locations. However, this size of fragmentation is low as compared to the national average of over 4 parcels per household reported in 1991/92 (CBS 1993a), but it is slightly greater than the average parcel size of 1.7 reported for the Chitwan district in 1991/92.

On average, about three-fifths (58 percent) of the total cultivated land was irrigated. However, a large majority of the households responded that most of their land was irrigated during the monsoon season only. This result suggests that there is no regular source of irrigation water during the drought season and an alternative source (for example, a pumpset) is required for regular water supply. About one-half (47 percent) of farm households cultivated both *khet* and *bari* land, about one-third households

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[1]Landless and near landless (0.0-0.5 hectare), subsistence (0.5-1.0 hectare), small (1.0-3.0 hectares), medium (3.0-5.0 hectares) and large (>5.0 hectares)

Table 5.1. Descriptive Statistics: Technology Use, Household Demographic, Socioeconomic and Neighborhood Characteristics, 1996 (N=1,225)

Variables	Descriptive Statistics			
	Mean	Std. Dev.	Minimum	Maximum
Technology use				
Package I: Bio-chemical technology use				
Fertilizer (used = 1)	0.83	0.38	0.00	1.00
Pesticides/ herbicides (used = 1)	0.23	0.42	0.00	1.00
Index				
Used both	0.21	0.41	0.00	1.00
Used any one	0.63	0.48	0.00	1.00
Package II: Mechanical technology use				
Tractor (used = 1)	0.77	0.42	0.00	1.00
Pumpset (own = 1)	0.04	0.19	0.00	1.00
Improved farm implements (own = 1)	0.14	0.35	0.00	1.00
Index				
Used any two or more	0.14	0.35	0.00	1.00
Used any one	0.66	0.48	0.00	1.00
Demographic characteristics				
Family size	5.76	2.54	1.00	26.00
Number of working age females/hectare	3.99	3.83	0.00	15.00
Number of working age males/hectare	3.91	3.94	0.00	15.00
Number of working age males and females/hectare	7.97	7.58	0.45	30.00
Age of head of the household (years)	41.78	12.52	15.00	80.00
Migration of individual from household (yes = 1)	0.25	0.43	0.00	1.00
Socioeconomic characteristics				
Total cultivated land (*kattha)*	25.04	23.44	1.00	200.00
Land fragmentation (number of parcels)	2.12	1.23	1.00	6.00
Irrigated land (percent)	58.14	41.46	0.00	100.00
Type (quality) of cultivated land				
Khet only (yes = 1)	0.31	0.46	0.00	1.00
Bari only (yes = 1)	0.22	0.41	0.00	1.00
Khet and *Bari* both (yes = 1)	0.47	0.50	0.00	1.00
Land ownership: Full-owners (yes = 1)	0.72	0.45	0.00	1.00
Part-owners (yes = 1)	0.20	0.40	0.00	1.00
Sharecroppers (yes = 1)	0.08	0.27	0.00	1.00
Livestock ownership (yes = 1)	0.90	0.30	0.00	1.00
Education of head of the household (years)	4.18	4.53	0.00	16.00
Ownership of radio and television (yes = 1)	0.54	0.50	0.00	1.00
Ethnicity: High Caste Hindu	0.49	0.50	0.00	1.00
Low Caste Hindu	0.11	0.32	0.00	1.00
Hill Tibetoburmese	0.16	0.37	0.00	1.00
Newar	0.06	0.24	0.00	1.00
Terai Tibetoburmese	0.18	0.39	0.00	1.00
Neighborhood characteristics				
Number of services within a 10-minute walk	0.77	0.70	0.00	3.00
Presence of Small Farmer Group (yes = 1)	0.20	0.40	0.00	1.00
Proximity to urban center				
Strata 1 (close to urban center)	0.23	0.42	0.00	1.00
Strata 2 (between strata 1 and 3)	0.33	0.47	0.00	1.00
Strata 3 (farthest from the urban center)	0.44	0.50	0.00	1.00

1 hectare = 1.5 *bigha* = 30 *kattha*

(31 percent) cultivated only *khet* land, and slightly over one-fifth (22 percent) of households cultivated only *bari* land.

On the ownership of land, 72 percent of the households were full owners, who owned the cultivated *bari* and/or *khet* land. These households had not sharecropped any parcel of land at the time of survey. About one-fifth (20 percent) of households owned some land as well as sharecropped (part-owners), while 8 percent fully sharecropped. As discussed previously, livestock are an integral part of the Chitwan Valley farming system. Ninety percent of the farming households kept animals such as cattle, buffalo, sheep, and goats. A farm household on average owned three large animals (cattle and buffalo) and about two small ruminants, sheep and goats (data not shown).

On average, the head of a household had slightly over four (4.18) years of schooling. Slightly less than a half (44.2 percent) of them were illiterate (no schooling), over 18 percent of them had primary level of schooling (1-5 years), 25 percent had between 6 and 10 years, and 13 percent had over 10 years of schooling (data not shown). Over one-half (54 percent) of the households owned either a radio or a television or both, which is used as a measure of the access to communication media.

One-half of the households belonged to the High Caste Hindu (for example, Brahmin and Chhetri), 18 percent of them belonged to the Terai Tibetoburmese group (for example, Tharu, Kumal, Darai), 16 percent belonged to the Hill Tibetoburmese (for example, Gurung, Magar, Kumal), 11 percent were from Low Caste Hindu (for example, Kami, Sunar, Damai) and only 6 percent of them were from the Newar ethnic group.

The access to services measured as the number of services i.e., banks, cooperatives, and bus services in the neighborhood within a 10-minute walk suggest that on average, less than one service (mean = 0.77) was available within a 10-minute walk. Of the total farm households, about 52 percent of them had at least one service available within a 10-minute walk. About 9 percent of them had two services, and about 2 percent of them had all the three services available within a 10-minute walk. The rest of the farming households (37 percent) had no access to these services within a 10-minute walk (data not shown). About 20 percent of the households belonged to a neighborhood where at least one member of the Small Farmer Development Program was present. About 23 percent of the households were living in the area close to the urban center (strata 1), 44 percent of them were living farthest from the urban center (strata 3) and the rest (33 percent) of them were living in between these two areas.

5.3.2. Bivariate Analysis

Since the major interest of this study is to examine the effect of the presence of working-age family labor on the use of technological inputs, Table 5.2 provides the results of the one-way ANOVA comparing the means of the presence of working-age labor pool in a household per unit of cultivated land between those who used and did not use fertilizers, pesticides, tractors, pumpsets, and improved implements, respectively.

The results indicate that households that used technological inputs had fewer family laborers per hectare of cultivated land as compared to those that did not use a technological input in question. For example, households that used chemical fertilizers, on average, had 7 persons per hectare of cultivated land as compared to 12 persons per hectare for those that did not use it. The mean difference is statistically significant (one-way ANOVA F; $p<.001$). The results are consistent when the means are compared by disaggregating family labor availability by gender. These results are consistent among those who used and did not use pesticides. Moreover, the magnitude of difference between those who used only one chemical input vs. both is rather small, but the difference between those who used vs. those who did not use any was quite significant.

Table 5.2. One-way ANOVA Results Comparing the Means of Family Labor Availability by Technology Use (N=1,225)

Variables	Working-age Family Members per Hectare of Cultivated Land		
	Total	Females	Males
Bio-chemical technology			
Chemical fertilizer			
Not used	12.16***	6.02***	5.95***
Used	7.10	3.57	3.49
Pesticides/herbicides			
Not used	8.45***	4.26***	4.15***
Used	6.41	3.14	3.15
Index			
Used none	12.49***	6.25***	6.14***
Used any one	7.52	3.78	3.68
Used both	6.09	3.03	3.01
Mechanical technology			
Tractor			
Not used	11.49***	5.74***	5.55***
Used	6.91	3.47	3.42
Pumpset			
Not owned	8.14***	4.07***	4.00***
Owned	3.65	1.96	1.69
Farm implements			
Not owned	8.67***	4.34***	4.26***
Owned	3.74	1.88	1.84
Index			
Used none	12.27***	6.13***	5.92***
Used any one	7.54	3.77	3.74
Used two or more	3.58	1.85	1.74

One-way ANOVA F *** = p<.001; ** = p<.01; * = p<.05; + = <.10
1 hectare = 1.5 *bigha* = 30 *kattha*

Similar results were obtained across mechanical inputs use. The households that did not use any mechanical input had significantly larger amounts of labor per unit of cultivated land compared with those who used any one or all the items of mechanical inputs considered in this study. These results suggest that households with fewer working-age family members per unit of cultivated land use modern inputs in crop production.

The bivariate correlation between the index of technology use packages, bio-chemical and mechanical, and the presence of working-age individuals (total, male and female) in a household per hectare of cultivated land also show a negative and statistically significant relationship (Table 5.3). Both of these results (from Tables 5.2 and 5.3) are consistent with the hypothesis that family labor availability reduces the likelihood of using labor-saving modern technological inputs in crop production. However, confirmation requires the multivariate analysis, the results of which are discussed below.

Table 5.3 also provides the bivariate association between technological packages and the remaining independent variables. Migration is weakly but positively associated with the use of bio-chemical inputs and the use of two or more items of mechanical inputs. Contrary to the hypothesized relationship, age is positively related to both technology use dimensions, but the relationship is statistically significant with the use of any one item of mechanical input only.

The results also indicate that most of the variables expressed a relationship with the technology use variables in the expected direction. Somewhat surprising was the association with land fragmentation, however. Increased number of parcels was positively associated with the use of both of the technological packages, except those who used only one item of mechanical technology, which was not statistically significant.

Table 5.3. Bivariate Correlations between Demographic, Socioeconomic and Neighborhood Characteristics and Technology Use Packages (N=1,225)

Variables	Bio-chemical		Mechanical	
	Use any one	Used both	Used any one	Used two or more
Demographic characteristics				
No. of working-age males and females/hectare	-0.078**	-0.129***	-0.078**	-0.232***
Number of working-age females/hectare land	-0.073**	-0.132***	-0.080**	-0.224***
Number of working-age males/hectare land	-0.076**	-0.119***	-0.061*	-0.221***
Age of head of the household (years)	0.029	0.042	0.099***	0.042
Migration of individual from household (yes=1)	0.015	0.049+	-0.007	0.049+
Socioeconomic characteristics				
Quality of cultivated land: *Bari* only (yes=1)	-0.056+	-0.041	0.003	-0.166***
Khet only (yes = 1)	-0.010	-0.019	0.001	0.002
Khet and *Bari* both (yes = 1)	0.055+	0.052+	-0.003	0.136***
Irrigated land (percent)	0.074*	0.093**	0.057+	0.093**
Fragmentation of holding (no. of land parcels)	0.080**	0.066*	-0.029	0.243***
Land ownership: Sharecroppers (yes = 1)	-0.014	-0.007**	0.005	-0.098***
Full owners (yes = 1)	-0.032	0.064*	-0.035	0.049+
Part-owners (yes = 1)	0.045	-0.020	0.036	0.011
Livestock ownership (yes = 1)	0.028	0.053+	-	-
Education of head of the household (years)	-0.002	0.133***	0.058*	0.103***
Ownership of radio and television (yes = 1)	0.012	0.090**	-0.047	0.167***
Ethnicity - High Caste Hindu	0.072*	0.091***	0.019	0.133***
Low Caste Hindu	-0.044	-0.061*	-0.022	-0.121***
Hill Tibetoburmese	-0.025	0.028	0.040	-0.039
Newar	0.060*	-0.037	0.006	0.021
Terai Tibetoburmese	-0.065*	-0.075**	-0.047	-0.047
Neighborhood characteristics				
No. of services within a 10-minute walk	0.009	0.024	0.068*	-0.027
Presence of Small Farmer Group (yes=1)	0.049*	-0.019	-0.050	0.045
Proximity to urban center: (Ref = strata 1)	0.055+	-0.024	0.073*	-0.117***
Strata 2 (between strata 1 and 3)	-0.147***	0.023	-0.002	-0.060*
Strata 3 (farthest from the urban center)	0.093***	-0.001	-0.060*	0.156***

t - statistics (two-tailed) *** = p<.001; ** = p<.01; * = p<.05; + = <.101
1 hectare = 1.5 *bigha* = 30 *kattha*

Pearson correlations were used as a collinearity diagnostic (results not shown). Since most of the relationships were well below 0.40 and a few of them were between 0.40 and 0.50 and considering a correlation of 0.70 or higher between two independent variables as collinear (Walsh 1990), the data show no serious collinearity problems except between labor availability per unit of land and their squared-terms. Moreover, the tolerance statistics of the SPSS OLS regression analysis also indicated no serious collinearity problems in the data. The tolerance statistics were well above 0.20, which was used as the bench mark for diagnosing collinearity problems as suggested by Menard (1995).

The bivariate associations described above indicate the magnitude and direction of association between dependent and independent variables and does not indicate a cause-effect relationship between the variables in question. Therefore, a multivariate analysis was used to examine the net effects of independent variables on the dependent variables, bio-chemical and mechanical technology use. The results of the multivariate analysis are described below.

5.3.3. Multivariate Results

Results in Tables 5.4 through 5.9 present the multivariate results predicting the effects of household demographic, socioeconomic and neighborhood characteristics on the use of bio-chemical and mechanical technologies. The results are presented as unstandardized β-coefficients and odds ratios (in parentheses) from multinomial logistic regression depicting the effects of various factors on bio-chemical (Tables 5.4 to 5.6) and mechanical (Tables 5.7 to 5.9) technology use, respectively.

The first table of each technology package (for example, Tables 5.4 and 5.7) provides the results in six different models. In model 1, I provide the effect of the presence of the total working-age family members (males plus females) per hectare of cultivated land on the use of specific technology package in question, while the results in model 2 include the effects of other demographic factors such as age of the household head and migration of any individual(s) from the household in addition to family labor per hectare of cultivated land. The results in model 3 and model 4 provide the effects of socioeconomic, and neighborhood characteristics, respectively. In model 5, I simultaneously added all the variables included in previous models (1 through 4). Finally, in model 6, I include the squared-term of labor availability to examine its curvilinear effect on technology use in addition to the effects of all other variables used in model 5.

The results in rest of the Tables (Tables 5.5, 5.6, 5.8, and 5.9) provide the effects of gender disaggregated female and male labor availability per hectare of cultivated land on technology use. While the Tables 5.5 and 5.6 present the effects of female and male labor availability per hectare of cultivated land, respectively, on the use of bio-chemical inputs, Tables 5.8 and 5.9 provide similar results for females and males, respectively, for the use of mechanical inputs. In model 1 of each table, I present the effects of female or male labor availability per unit of cultivated land on input use. Model 2 includes other demographic characteristics such as the age of the household head and migration of individuals from the household. In model 3, I included household socioeconomic and neighborhood characteristics along with household demographic characteristics included in model 2. In model 4, I added the squared-term of female or male labor availability per unit of cultivated land along with all other variables. In model 5 (only in Tables 5.5 and 5.8), I included the effects of number of working-age females and males per unit of cultivated land simultaneously. In the final model (model 6), I added the squared-terms of male and female labor availability.

The results are provided in two panels. The results in the top panel compare the effects of various factors on technology use between households that used any one technology versus those that did not use any. The results in the bottom panel compare the

Table 5.4. Multinomial Logistic Regression Models Predicting the Effects of Demographic, Socioeconomic and Neighborhood Characteristics on Bio-Chemical Technology Use (Total), (N=1,225)

Variables	Models					
	1	2	3	4	5	6
Used any one input vs. None						
Intercept	2.069***	1.860***	0.392	1.701***	0.928	0.815
Demographic characteristics						
Number of working-age males and females/*hectare*	-0.066 (0.936)***	-0.066 (0.937)***	-	-	-0.026 (0.975)*	-0.008 (0.992)
Number of working-age labor/*hectare* squared	-	-	-	-	-	-0.001 (0.999)
Other						
Age of head of the household (years)	-	0.004 (1.004)	-	-	0.004 (1.004)	0.004 (1.004)
Migration of individual from household (yes=1)	-	0.133 (1.142)	-	-	-0.086 (0.918)	-0.097 (0.908)
Socioeconomic characteristics						
Irrigated land (percent)	-	-	0.001 (1.001)	-	0.002 (1.002)	0.002 (1.002)
Land ownership (Ref= Sharecroppers)						
Full owners (yes=1)	-	-	0.098 (1.103)	-	0.293 (1.340)	0.298 (1.347)
Part-owners (yes=1)	-	-	-0.160 (0.863)	-	-0.056 (0.945)	-0.047 (0.955)
Fragmentation of holding (no. of land parcels)	-	-	0.632 (1.869)***	-	0.449 (1.567)***	0.458 (1.581)***
Livestock ownership (yes=1)	-	-	0.177 (1.193)	-	0.102 (1.108)	0.099 (1.104)
Education of head of the household (years)	-	-	0.049 (1.050)*	-	0.051 (1.052)+	0.052 (1.053)+
Ownership of radio and television (yes=1)	-	-	0.139 (1.149)	-	0.130 (1.139)	0.135 (1.144)
Ethnicity (Ref=High Caste Hindu)						
Low Caste Hindu	-	-	-0.996 (0.369)***	-	-0.801 (0.449)**	-0.807 (0.446)**
Hill Tibetoburmese	-	-	-0.467 (0.627)+	-	-0.200 (0.818)	-0.201 (0.818)
Newar	-	-	-0.067 (0.935)	-	0.011 (1.011)	0.010 (1.010)
Terai Tibetoburmese	-	-	-1.445 (0.236)***	-	-1.437 (0.238)***	-1.445 (0.236)***
Neighborhood characteristics						
No. of services within a 10-minute walk	-	-	-	0.055 (1.057)	-0.160 (0.852)	-0.161 (0.851)
Presence of Small Farmer Group (yes=1)	-	-	-	-0.331 (0.718)	-0.516 (0.597)+	-0.514 (0.598)
Proximity to urban center (Ref=strata 1)						
Strata 2 (between strata 1 and 3)	-	-	-	-0.951 (0.387)***	-0.860 (0.423)***	-0.848 (0.428)***
Strata 3 (farthest from the urban center)	-	-	-	0.319 (1.376)	0.552 (1.737)+	0.571 (1.770)+

Table 5.4 continued

Table 5.4 continued

Variables	Models					
	1	2	3	4	5	6
Used both inputs vs. None						
Intercept	1.229***	1.004**	-1.948***	0.512*	-1.377+	-1.250
Demographic characteristics						
Number of working-age males and females/*hectare*	-0.103 (0.903)***	-0.103 (0.902)***	-	-	-0.052 (0.949)**	-0.075 (0.928)
Number of working-age labor/*hectare* squared	-	-	-	-	-	0.001 (1.001)
Other						
Age of head of the household (years)	-	0.004 (1.004)	-	-	0.013 (1.014)	0.013 (1.013)
Migration of individual from household (yes=1)	-	0.219 (1.244)	-	-	-0.075 (0.928)	-0.058 (0.944)
Socioeconomic characteristics						
Irrigated land (percent)	-	-	0.003 (1.003)	-	0.004 (1.004)	0.004 (1.004)
Land ownership (Ref= Sharecroppers)						
Full owners (yes=1)	-	-	0.664 (1.943)	-	0.850 (2.340)*	0.838 (2.311)*
Part-owners (yes=1)	-	-	0.171 (1.187)	-	0.189 (1.208)	0.168 (1.183)
Fragmentation of holding (no. of land parcels)	-	-	0.720 (2.054)***	-	0.493 (1.638)***	0.488 (1.110)***
Livestock ownership (yes=1)	-	-	0.307 (1.359)	-	-0.010 (0.990)	-0.006 (0.994)
Education of head of the household (years)	-	-	0.094 (1.099)***	-	0.106 (1.111)***	0.105 (1.110)***
Ownership of radio and television (yes=1)	-	-	0.357 (1.430)+	-	0.335 (1.399)	0.331 (1.392)
Ethnicity (Ref=High Caste Hindu)						
Low Caste Hindu	-	-	-1.081 (0.339)**	-	-0.777 (0.460)*	-0.778 (0.459)*
Hill Tibetoburmese	-	-	-0.244 (0.783)	-	-0.025 (0.975)	-0.030 (0.970)
Newar	-	-	-0.673 (0.510)	-	-0.582 (0.559)	-0.585 (0.557)
Terai Tibetoburmese	-	-	-1.562 (0.210)***	-	-1.480 (0.228)***	-1.477 (0.228)***
Neighborhood characteristics						
No. of services within a 10-minute walk	-	-	-	-0.058 (0.943)	-0.316 (0.729)+	-0.313 (0.732)+
Presence of Small Farmer Group (yes=1)	-	-	-	-0.434 (0.648)	-0.642 (0.526)+	-0.643 (0.526)+
Proximity to urban center (Ref=strata 1)						
Strata 2 (between strata 1 and 3)	-	-	-	-0.513 (0.599)+	-0.443 (0.642)	-0.460 (0.631)
Strata 3 (farthest from the urban center)	-	-	-	0.475 (1.608)	0.739 (2.095)*	0.716 (2.046)+
Chi-Square	74.743***	75.967***	169.975***	43.073***	226.869***	228.013***
-2 Log likelihood	780.280	2033.805	1727.867	141.735	1989.992	1988.848
Degrees of freedom	2	6	22	8	36	38
McFadden Pseudo R-square	0.034	0.034	0.102	0.019	0.102	0.103

t-statistic *** = p<.001; ** = p<.01; * = p<.05; + = <.10   1 hectare = 1.5 *bigha* = 30 *kattha*   Figures in parentheses are odds ratios.

Table 5.5. Multinomial Logistic Regression Models Predicting the Effects of Demographic, Socioeconomic and Neighborhood Characteristics on Bio-Chemical Technology Use (Females), (N=1,225)

Variables	Models					
	1	2	3	4	5	6
Used any one item vs. None						
Intercept	2.059***	1.844***	0.950	0.954	0.978	0.989
Demographic characteristics						
Number of working-age females/*hectare*	-0.129 (0.879)***	-0.128 (0.880)***	-0.052 (0.949)*	-0.049 (0.952)	-0.035 (0.966)	-0.039 (0.961)
Number of working-age females/*hectare* squared	-	-	-	0.000 (1.000)	-	0.000 (1.000)
Number of working-age males/*hectare*	-	-	-	-	-0.021 (0.979)	-0.018 (0.982)
Number of working-age males/*hectare* squared	-	-	-	-	-	0.000 (1.000)
Other						
Age of head of the household (years)	-	0.004 (1.004)	0.004 (1.004)	0.003 (1.003)	0.003 (1.003)	0.003 (1.003)
Migration of individual from household (yes=1)	-	0.113 (1.120)	-0.090 (0.914)	-0.092 (0.912)	-0.083 (0.921)	-0.082 (0.921)
Socioeconomic characteristics						
Irrigated land (percent)	-	-	0.002 (1.002)	0.002 (1.002)	0.002 (1.002)	0.002 (1.002)
Land ownership (Ref= Sharecroppers)						
Full owners (yes=1)	-	-	0.318 (1.374)	0.318 (1.375)	0.311 (1.365)	0.308 (1.361)
Part-owners (yes=1)	-	-	-0.038 (0.963)	-0.037 (0.964)	-0.046 (0.955)	-0.050 (0.951)
Fragmentation of holding (no. of land parcels)	-	-	0.446 (1.563)***	0.446 (1.561)***	0.442 (1.556)***	0.441 (1.554)***
Livestock ownership (yes=1)	-	-	0.080 (1.083)	0.079 (1.083)	0.089 (1.093)	0.090 (1.095)
Education of head of the household (years)	-	-	0.049 (1.050)+	0.049 (1.050)+	0.049 (1.050)+	0.049 (1.050)+
Ownership of radio and television (yes=1)	-	-	0.132 (1.141)	0.133 (1.142)	0.126 (1.134)	0.126 (1.134)
Ethnicity (Ref=High Caste Hindu)						
Low Caste Hindu	-	-	-0.832 (0.435)**	-0.833 (0.435)**	-0.807 (0.446)**	-0.809 (0.445)**
Hill Tibetoburmese	-	-	-0.211 (0.809)	-0.212 (0.809)	-0.206 (0.814)	-0.207 (0.813)
Newar	-	-	-0.005 (0.995)	-0.004 (0.996)	0.005 (1.005)	0.006 (1.006)
Terai Tibetoburmese	-	-	-1.449 (0.235)***	-1.448 (0.235)***	-1.439 (0.237)***	-1.438 (0.237)***
Neighborhood characteristics						
No. of services within a 10-minute walk	-	-	-0.160 (0.852)	-0.161 (0.851)	-0.159 (0.853)	-0.160 (0.852)
Presence of Small Farmer Group (yes=1)	-	-	-0.520 (0.595)+	-0.519 (0.595)+	-0.521 (0.594)+	-0.520 (0.595)+
Proximity to urban center (Ref=strata 1)						
Strata 2 (between strata 1 and 3)	-	-	-0.853 (0.426)***	-0.850 (0.427)***	-0.862 (0.422)***	-0.859 (0.424)***
Strata 3 (farthest from the urban center)	-	-	0.563 (1.756)+	0.564 (1.758)+	0.553 (1.739)+	0.553 (1.739)+

Table 5.5 continued

Table 5.5 continued

Variables	Models					
	1	2	3	4	5	6
Used both items vs. None						
Intercept	1.225***	0.982**	-1.338+	-1.079	-1.306+	-1.105
Demographic characteristics						
Number of working-age females/*hectare*	-0.204 (0.815)***	-0.204 (0.815)***	-0.108 (0.898)***	-0.207 (0.813)*	-0.091 (0.913)+	-0.240 (0.787)*
Number of working-age females/*hectare* squared	-	-	-	0.007 (1.007)	-	0.012 (1.012)
Number of working-age males/*hectare*	-	-	-	-	-0.021 (0.979)	0.049 (1.050)
Number of working-age males/*hectare* squared	-	-	-	-	-	-0.006 (0.994)
Other						
Age of head of the household (years)	-	0.005 (1.005)	0.013 (1.013)	0.013 (1.013)	0.013 (1.013)	0.014 (1.014)
Migration of individual from household (yes=1)	-	0.198 (1.219)	-0.081 (0.922)	-0.045 (0.956)	-0.073 (0.929)	-0.039 (0.962)
Socioeconomic characteristics						
Irrigated land (percent)	-	-	0.004 (1.004)	0.004 (1.004)	0.004 (1.004)	0.004 (1.004)
Land ownership (Ref= Sharecroppers)						
Full owners (yes=1)	-	-	0.884 (2.421)*	0.846 (2.331)*	0.878 (2.407)*	0.831 (2.296)*
Part-owners (yes=1)	-	-	0.211 (1.234)	0.155 (1.167)	0.203 (1.225)	0.133 (1.142)
Fragmentation of holding (no. of land parcels)	-	-	0.487 (1.627)***	0.472 (1.603)***	0.482 (1.620)***	0.471 (1.602)***
Livestock ownership (yes=1)	-	-	-0.040 (0.960)	-0.006 (0.994)	-0.033 (0.968)	0.011 (1.011)
Education of head of the household (years)	-	-	0.103 (1.108)***	0.101 (1.106)***	0.103 (1.108)***	0.101 (1.107)***
Ownership of radio and television (yes=1)	-	-	0.338 (1.402)	0.329 (1.389)	0.332 (1.394)	0.318 (1.374)
Ethnicity (Ref=High Caste Hindu)						
Low Caste Hindu	-	-	-0.819 (0.441)*	-0.818 (0.441)*	-0.794 (0.452)*	-0.792 (0.453)*
Hill Tibetoburmese	-	-	-0.042 (0.959)	-0.054 (0.947)	-0.036 (0.965)	-0.052 (0.949)
Newar	-	-	-0.597 (0.550)	-0.586 (0.557)	-0.588 (0.556)	-0.559 (0.572)
Terai Tibetoburmese	-	-	-1.494 (0.225)***	-1.482 (0.227)***	-1.483 (0.227)***	-1.470 (0.230)***
Neighborhood characteristics						
No. of services within a 10-minute walk	-	-	-0.315 (0.730)+	-0.311 (0.733)+	-0.313 (0.731)+	-0.312 (0.732)+
Presence of Small Farmer Group (yes=1)	-	-	-0.648 (0.523)+	-0.651 (0.522)+	-0.649 (0.523)+	-0.653 (0.520)+
Proximity to urban center (Ref=strata 1)						
Strata 2 (between strata 1 and 3)	-	-	-0.431 (0.650)	-0.463 (0.630)	-0.441 (0.643)	-0.465 (0.628)
Strata 3 (farthest from the urban center)	-	-	0.758 (2.133)*	0.715 (2.044)+	0.747 (2.112)*	0.715 (2.044)+
Chi-Square	64.280***	75.409***	227.953***	229.901***	228.344***	231.095***
-2 Log likelihood	642.485	1984.196	1988.908	1986.960	1988.517	1985.766
Degrees of freedom	2	6	36	38	40	42
McFadden Pseudo R-square	0.034	0.034	0.103	0.104	0.103	0.104

t-statistic *** = p<.001; ** = p<.01; * = p<.05; + = <.10 1 hectare = 1.5 *bigha* = 30 *kattha* Figures in parentheses are odds ratios.

Table 5.6. Multinomial Logistic Regression Models Predicting the Effects of Demographic, Socioeconomic and Neighborhood Characteristics on Bio-Chemical Technology Use (Males), (N=1,225)

Variables	Models			
	1	2	3	4
Used any one item vs. None				
Intercept	2.014***	1.800***	0.850	0.790
Demographic characteristics				
Number of working-age males/*hectare*	-0.122 (0.885)***	-0.122 (0.885)***	-0.046 (0.955)*	-0.027 (0.974)
Number of working-age males/*hectare* squared	-	-	-	-0.001 (0.999)
Other				
Age of head of the household (years)	-	0.004 (1.004)	0.004 (1.004)	0.004 (1.004)
Migration of individual from household (yes=1)	-	0.145 (1.156)	-0.083 (0.920)	-0.089 (0.915)
Socioeconomic characteristics				
Irrigated land (percent)	-	-	0.002 (1.002)	0.002 (1.002)
Land ownership (Ref= Sharecroppers)				
Full owners (yes=1)	-	-	0.268 (1.307)	0.272 (1.312)
Part-owners (yes=1)	-	-	-0.066 (0.936)	-0.063 (0.939)
Fragmentation of holding (no. of land parcels)	-	-	0.466 (1.593)***	0.470 (1.600)***
Livestock ownership (yes=1)	-	-	0.138 (1.148)	0.133 (1.143)
Education of head of the household (years)	-	-	0.052 (1.054)+	0.053 (1.054)+
Ownership of radio and television (yes=1)	-	-	0.127 (1.135)	0.127 (1.136)
Ethnicity (Ref=High Caste Hindu)				
Low Caste Hindu	-	-	-0.798 (0.450)**	-0.802 (0.449)**
Hill Tibetoburmese	-	-	-0.202 (0.817)	-0.202 (0.817)
Newar	-	-	0.011 (1.011)	0.011 (1.011)
Terai Tibetoburmese	-	-	-1.450 (0.235)***	-1.454 (0.234)***
Neighborhood characteristics				
No. of services within a 10-minute walk	-	-	-0.158 (0.853)	-0.159 (0.853)
Presence of Small Farmer Group (yes=1)	-	-	-0.515 (0.597)	-0.515 (0.598)
Proximity to urban center (Ref=strata 1)				
Strata 2 (between strata 1 and 3)	-	-	-0.861 (0.423)***	-0.855 (0.425)***
Strata 3 (farthest from the urban center)	-	-	0.554 (1.740)+	0.563 (1.756)+

Table 5.6 continued

Table 5.6 continued

Variables	Models			
	1	2	3	4
Used both items vs. None				
Intercept	1.129***	0.906*	-1.575*	-1.625*
Demographic characteristics				
Number of working-age males/*hectare*	-0.183 (0.833)***	-0.184 (0.832)***	-0.084 (0.919)**	-0.068 (0.934)
Number of working-age males/*hectare* squared	-	-	-	-0.001 (0.999)
Other				
Age of head of the household (years)	-	0.004 (1.004)	0.013 (1.013)	0.014 (1.014)
Migration of individual from household (yes=1)	-	0.232 (1.261)	-0.076 (0.926)	-0.081 (0.922)
Socioeconomic characteristics				
Irrigated land (percent)	-	-	0.004 (1.004)	0.004 (1.004)
Land ownership (Ref= Sharecroppers)				
Full owners (yes=1)	-	-	0.814 (2.257)+	0.817 (2.264)+
Part-owners (yes=1)	-	-	0.182 (1.199)	0.184 (1.202)
Fragmentation of holding (no. of land parcels)	-	-	0.524 (1.688)***	0.527 (1.695)***
Livestock ownership (yes=1)	-	-	0.069 (1.072)	0.065 (1.068)
Education of head of the household (years)	-	-	0.108 (1.115)***	0.109 (1.115)***
Ownership of radio and television (yes=1)	-	-	0.335 (1.397)	0.335 (1.398)
Ethnicity (Ref=High Caste Hindu)				
Low Caste Hindu	-	-	-0.785 (0.456)*	-0.789 (0.454)*
Hill Tibetoburmese	-	-	-0.026 (0.975)	-0.026 (0.935)
Newar	-	-	-0.581 (0.559)	-0.581 (0.559)
Terai Tibetoburmese	-	-	-1.509 (0.221)***	-1.513 (0.220)***
Neighborhood characteristics				
No. of services within a 10-minute walk	-	-	-0.317 (0.729)+	-0.317 (0.728)+
Presence of Small Farmer Group (yes=1)	-	-	-0.639 (0.528)+	-0.638 (0.528)+
Proximity to urban center (Ref=strata 1)				
Strata 2 (between strata 1 and 3)	-	-	-0.441 (0.643)	-0.436 (0.647)
Strata 3 (farthest from the urban center)	-	-	0.746 (2.108)*	0.753 (2.123)*
Chi-Square	66.618***	67.962***	224.617***	224.676***
-2 Log likelihood	629.791	1993.369	1992.244	1992.185
Degrees of freedom	2	6	36	38
McFadden Pseudo R-square	0.030	0.031	0.101	0.101

t-statistic *** = p<.001; ** = p<.01; * = p<.05; + = <.10 Figures in parentheses are odds ratios 1 hectare = 1.5 *bigha* = 30 *kattha*

Table 5.7. Multinomial Logistic Regression Models Predicting the Effects of Demographic, Socioeconomic and Neighborhood Characteristics on Mechanical Technology Use (Total), (N=1,225)

Variables	Models					
	1	2	3	4	5	6
Used any one input vs. None						
Intercept	1.801***	2.087***	0.015	1.049***	1.162	1.270
Demographic characteristics						
Number of working-age males and females/*hectare*	-0.067 (0.935)***	-0.070 (0.932)***	-	-	-0.054 (0.948)***	-0.067 (0.935)+
Number of working-age labor/*hectare* squared	-	-	-	-	-	0.000 (1.000)
Other						
Age of head of the household (years)	-	-0.009 (0.991)	-	-	-0.007 (0.993)	-0.007 (0.993)
Migration of individual from household (yes=1)	-	0.537 (1.711)**	-	-	0.461 (1.586)*	0.468 (1.597)*
Socioeconomic characteristics						
Quality of land (Ref=*Bari* only)						
Khet only	-	-	0.212 (1.236)	-	0.176 (1.192)	0.166 (1.181)
Khet and *Bari* only	-	-	0.195 (1.215)	-	-0.063 (0.939)	-0.073 (0.930)
Land ownership (Ref= Sharecroppers)						
Full owners (yes=1)	-	-	0.013 (1.013)	-	0.235 (1.264)	0.230 (1.259)
Part-owners (yes=1)	-	-	0.030 (1.030)	-	0.124 (1.132)	0.113 (1.119)
Fragmentation of holding (no. of land parcels)	-	-	0.336 (1.339)**	-	0.211 (1.234)*	0.206 (1.228)*
Livestock ownership (yes=1)	-	-	0.322 (1.380)	-	0.150 (1.162)	0.149 (1.161)
Education of head of the household (years)	-	-	0.071 (1.074)***	-	0.044 (1.045)+	0.043 (1.044)+
Ownership of radio and television (yes=1)	-	-	-0.008 (0.992)	-	-0.078 (0.925)	-0.082 (0.921)
Ethnicity (Ref=High Caste Hindu)						
Low Caste Hindu	-	-	-0.540 (0.583)*	-	-0.483 (0.617)+	-0.479 (0.620)+
Hill Tibetoburmese	-	-	0.089 (1.094)	-	-0.012 (0.988)	-0.015 (0.985)
Newar	-	-	0.007 (1.007)	-	-0.050 (0.951)	-0.048 (0.953)
Terai Tibetoburmese	-	-	-0.583 (0.558)**	-	-0.384 (0.681)+	-0.382 (0.683)
Neighborhood characteristics						
No. of services within a 10-minute walk	-	-	-	0.284 (1.328)**	0.257 (1.293)*	0.258 (1.294)*
Presence of Small Farmer Group (yes=1)	-	-	-	-0.549 (0.577)*	-0.739 (0.477)**	-0.743 (0.476)**
Proximity to urban center (Ref=strata 1)						
Strata 2 (between strata 1 and 3)	-	-	-	-0.283 (0.753)	-0.381 (0.683)+	-0.390 (0.677)+
Strata 3 (farthest from the urban center)	-	-	-	0.260 (1.296)	0.172 (1.188)	0.155 (1.168)

Table 5.7 continued

Table 5.7 continued

Variables	Models					
	1	2	3	4	5	6
Used two or more items vs. None						
Intercept	1.485***	0.966*	-6.226***	-1.252***	-4.928***	-4.126***
Demographic characteristics						
Number of working-age males and females/*hectare*	-0.323 (0.724)***	-0.335 (0.715)***	-	-	-0.209 (0.812)***	-0.424 (0.655)***
Number of working-age labor/*hectare* squared	-	-	-	-	-	0.010 (1.010)***
Other						
Age of head of the household (years)	-	0.009 (1.009)	-	-	0.018 (1.019)+	0.018 (1.019)+
Migration of individual from household (yes=1)	-	0.816 (2.261)**	-	-	0.546 (1.727)+	0.682 (1.978)*
Socioeconomic characteristics						
Quality of land (Ref=*Bari* only)						
Khet only	-	-	1.541 (4.670)***	-	1.299 (3.667)**	1.290 (3.631)**
Khet and *Bari* only	-	-	1.422 (4.146)***	-	0.671 (1.956)	0.619 (1.857)
Land ownership (Ref= Sharecroppers)						
Full owners (yes=1)	-	-	1.523 (4.587)*	-	1.899 (6.676)*	1.937 (6.940)*
Part-owners (yes=1)	-	-	1.068 (2.911)	-	1.097 (2.996)	1.092 (2.981)
Fragmentation of holding (no. of land parcels)	-	-	0.793 (2.210)***	-	0.488 (1.628)***	0.455 (1.576)***
Livestock ownership (yes=1)	-	-	0.920 (2.509)+	-	0.075 (1.078)	0.056 (1.057)
Education of head of the household (years)	-	-	0.098 (1.102)***	-	0.101 (1.106)***	0.098 (1.104)**
Ownership of radio and television (yes=1)	-	-	0.812 (2.252)***	-	0.731 (2.076)**	0.708 (2.031)**
Ethnicity (Ref=High Caste Hindu)						
Low Caste Hindu	-	-	-1.976 (0.139)**	-	-1.758 (0.172)**	-1.709 (0.181)**
Hill Tibetoburmese	-	-	-0.021 (0.979)	-	-0.234 (0.791)	-0.254 (0.776)
Newar	-	-	-0.020 (0.980)	-	0.033 (1.033)	0.002 (1.002)
Terai Tibetoburmese	-	-	-1.029 (0.357)**	-	-0.703 (0.495)+	-0.659 (0.517)+
Neighborhood characteristics						
No. of services within a 10-minute walk	-	-	-	0.064 (1.067)	0.073 (1.075)	0.079 (1.082)
Presence of Small Farmer Group (yes=1)	-	-	-	-0.735 (0.479)**	-1.361 (0.256)***	-1.373 (0.253)***
Proximity to urban center (Ref=strata 1)						
Strata 2 (between strata 1 and 3)	-	-	-	0.418 (1.519)	0.183 (1.201)	0.084 (1.088)
Strata 3 (farthest from the urban center)	-	-	-	1.663 (5.273)***	1.622 (5.065)***	1.503 (4.494)***
Chi-Square	183.455***	203.528***	230.147***	51.424***	341.146***	354.178***
-2 Log likelihood	760.876	1837.593	1404.963	145.733	1804.761	1791.729
Degrees of freedom	2	6	24	8	38	40
McFadden Pseudo R-square	0.085	0.095	0.107	0.024	0.159	0.165

t-statistic *** = p<.001; ** = p<.01; * = p<.05; + = <.10 1 hectare = 1.5 *bigha* = 30 *kattha* Figures in parentheses are odds ratios.

Table 5.8. Multinomial Logistic Regression Models Predicting the Effects of Demographic, Socioeconomic and Neighborhood Characteristics on Mechanical Technology Use (Females), (N=1,225)

Variables	Models					
	1	2	3	4	5	6
Used any one item vs. None						
Intercept	1.791***	2.057***	1.155*	1.093+	1.196*	1.159+
Demographic characteristics						
Number of working-age females/*hectare*	-0.132 (0.876)***	-0.137 (0.872)***	-0.105 (0.900)***	-0.080 (0.948)	-0.089 (0.915)**	-0.065 (0.937)
Number of working-age females/*hectare* squared	-	-	-	-0.002 (0.998)	-	-0.002 (0.998)
Number of working-age males/*hectare*	-	-	-	-	-0.021 (0.979)	-0.027 (0.973)
Number of working-age males/*hectare* squared	-	-	-	-	-	0.000 (1.000)
Other						
Age of head of the household (years)	-	-0.009 (0.991)	-0.007 (0.993)	-0.007 (0.993)	-0.007 (0.993)	-0.007 (0.993)
Migration of individual from household (yes=1)	-	0.516 (1.676)**	0.448 (1.566)*	0.438 (1.550)*	0.459 (1.583)*	0.452 (1.571)*
Socioeconomic characteristics						
Quality of land (Ref=*Bari* only)						
Khet only	-	-	0.170 (1.186)	0.171 (1.186)	0.172 (1.188)	0.172 (1.187)
Khet and *Bari* only	-	-	-0.073 (0.930)	-0.072 (0.931)	-0.077 (0.926)	-0.076 (0.927)
Land ownership (Ref= Sharecroppers)						
Full owners (yes=1)	-	-	0.274 (1.315)	0.282 (1.326)	0.268 (1.308)	0.276 (1.318)
Part-owners (yes=1)	-	-	0.158 (1.171)	0.170 (1.185)	0.149 (1.161)	0.161 (1.174)
Fragmentation of holding (no. of land parcels)	-	-	0.212 (1.236)*	0.218 (1.244)*	0.209 (1.232)*	0.213 (1.238)*
Livestock ownership (yes=1)	-	-	0.122 (1.130)	0.109 (1.115)	0.128 (1.137)	0.118 (1.125)
Education of head of the household (years)	-	-	0.042 (1.043)+	0.042 (1.043)+	0.042 (1.043)+	0.042 (1.043)+
Ownership of radio and television (yes=1)	-	-	-0.073 (0.930)	-0.072 (0.930)	-0.079 (0.924)	-0.078 (0.925)
Ethnicity (Ref=High Caste Hindu)						
Low Caste Hindu	-	-	-0.544 (0.580)*	-0.543 (0.581)*	-0.518 (0.596)*	-0.518 (0.596)*
Hill Tibetoburmese	-	-	-0.031 (0.969)	-0.029 (0.971)	-0.025 (0.975)	-0.024 (0.976)
Newar	-	-	-0.071 (0.932)	-0.075 (0.927)	-0.061 (0.941)	-0.065 (0.937)
Terai Tibetoburmese	-	-	-0.405 (0.667)+	-0.411 (0.663)+	-0.393 (0.675)+	-0.398 (0.671)+
Neighborhood characteristics						
No. of services within a 10-minute walk	-	-	0.255 (1.291)*	0.253 (1.288)*	0.257 (1.292)*	0.255 (1.291)*
Presence of Small Farmer Group (yes=1)	-	-	-0.743 (0.476)**	-0.741 (0.477)**	-0.743 (0.476)**	-0.741 (0.477)**
Proximity to urban center (Ref=strata 1)						
Strata 2 (between strata 1 and 3)	-	-	-0.361 (0.697)+	-0.356 (0.700)+	-0.373 (0.689)+	-0.371 (0.690)+
Strata 3 (farthest from the urban center)	-	-	0.199 (1.220)	0.207 (1.229)	0.184 (1.202)	0.188 (1.207)

Table 5.8 continued

Table 5.8 continued

Variables	Models					
	1	2	3	4	5	6
Used two or more items vs. None						
Intercept	1.285***	0.667	-5.359***	-4.922***	-4.912***	-4.319***
Demographic characteristics						
Number of working-age females/*hectare*	-0.553 (0.575)***	-0.571 (0.565)***	-0.357 (0.700)***	-0.676 (0.509)***	-0.274 (0.760)***	-0.545 (0.580)***
Number of working-age females/*hectare* squared	-	-	-	0.031 (1.032)***	-	0.026 (1.027)*
Number of working-age males/*hectare*	-	-	-	-	-0.146 (0.864)+	-0.274 (0.760)+
Number of working-age males/*hectare* squared	-	-	-	-	-	0.012 (1.012)
Other						
Age of head of the household (years)	-	0.011 (1.011)	0.020 (1.020)+	0.098 (1.103)**	0.018 (1.019)+	0.018 (1.018)
Migration of individual from household (yes=1)	-	0.744 (2.104)**	0.486 (1.625)+	0.583 (1.791)*	0.542 (1.719)+	0.673 (1.961)*
Socioeconomic characteristics						
Quality of land (Ref=*Bari* only)						
Khet only	-	-	1.361 (3.900)**	1.399 (4.049)**	1.303 (3.679)**	1.354 (3.871)**
Khet and *Bari* only	-	-	0.755 (2.128)+	0.768 (2.155)+	0.666 (1.946)	0.676 (1.967)
Land ownership (Ref= Sharecroppers)						
Full owners (yes=1)	-	-	1.918 (6.809)*	1.933 (6.910)*	1.926 (6.865)*	1.958 (7.087)*
Part-owners (yes=1)	-	-	1.117 (3.057)	1.092 (2.980)	1.114 (3.047)	1.106 (3.022)
Fragmentation of holding (no. of land parcels)	-	-	0.500 (1.648)***	0.482 (1.620)***	0.484 (1.623)***	0.461 (1.586)***
Livestock ownership (yes=1)	-	-	0.176 (1.192)	0.223 (1.249)	0.067 (1.069)	0.104 (1.109)
Education of head of the household (years)	-	-	0.100 (1.105)**	0.098 (1.103)**	0.098 (1.103)**	0.096 (1.101)**
Ownership of radio and television (yes=1)	-	-	0.748 (2.112)**	0.728 (2.071)**	0.728 (2.071)**	0.709 (2.031)**
Ethnicity (Ref=High Caste Hindu)						
Low Caste Hindu	-	-	-1.888 (0.151)**	-1.885 (0.152)**	-1.797 (0.166)**	-1.751 (0.174)**
Hill Tibetoburmese	-	-	-0.273 (0.761)	-0.298 (0.742)	-0.251 (0.778)	-0.270 (0.763)
Newar	-	-	0.058 (1.059)	0.076 (1.079)	0.034 (1.035)	0.028 (1.028)
Terai Tibetoburmese	-	-	-0.763 (0.466)*	-0.730 (0.482)*	-0.712 (0.491)+	-0.669 (0.512)+
Neighborhood characteristics						
No. of services within a 10-minute walk	-	-	0.064 (1.066)	0.062 (1.064)	0.072 (1.074)	0.072 (1.075)
Presence of Small Farmer Group (yes=1)	-	-	-1.380 (0.252)***	-1.404 (0.246)***	-1.367 (0.255)***	-1.376 (0.253)***
Proximity to urban center (Ref=strata 1)						
Strata 2 (between strata 1 and 3)	-	-	0.252 (1.286)	0.173 (1.189)	0.194 (1.214)	0.098 (1.102)
Strata 3 (farthest from the urban center)	-	-	1.734 (5.665)***	1.668 (5.301)***	1.642 (5.163)***	1.541 (4.671)***
Chi-Square	166.945***	186.752***	337.689***	348.182***	341.155***	353.469***
-2 Log likelihood	659.442	1815.762	1808.218	1797.725	1804.752	1792.438
Degrees of freedom	2	6	38	40	38	44
McFadden Pseudo R-square	0.078	0.087	0.157	0.162	0.159	0.165

t-statistic *** = p<.001; ** = p<.01; * = p<.05; + = <.10 1 hectare = 1.5 *bigha* = 30 *kattha* Figures in parentheses are odds ratios.

Table 5.9. Multinomial Logistic Regression Models Predicting the Effects of Demographic, Socioeconomic and Neighborhood Characteristics on Mechanical Technology Use (Males), (N=1,225)

Variables	Models			
	1	2	3	4
Used any one items vs. None				
Intercept	1.700***	1.977***	0.886	0.720
Demographic characteristics				
Number of working-age males/*hectare*	-0.116 (0.891)***	-0.122 (0.885)***	-0.081 (0.922)***	-0.027 (0.973)
Number of working-age males/*hectare* squared	-	-	-	-0.003 (0.997)
Other				
Age of head of the household (years)	-	-0.009 (0.991)	-0.007 (0.993)	-0.006 (0.994)
Migration of individual from household (yes=1)	-	0.539 (1.714)**	0.442 (1.556)*	0.423 (1.526)*
Socioeconomic characteristics				
Quality of land (Ref=*Bari* only)				
Khet only	-	-	0.224 (1.251)	0.230 (1.259)
Khet and *Bari* only	-	-	0.021 (1.021)	0.030 (1.030)
Land ownership (Ref= Sharecroppers)				
Full owners (yes=1)	-	-	0.176 (1.192)	0.185 (1.204)
Part-owners (yes=1)	-	-	0.108 (1.114)	0.120 (1.127)
Fragmentation of holding (no. of land parcels)	-	-	0.244 (1.276)*	0.254 (1.289)**
Livestock ownership (yes=1)	-	-	0.240 (1.272)	0.227 (1.255)
Education of head of the household (years)	-	-	0.048 (1.049)*	0.049 (1.050)*
Ownership of radio and television (yes=1)	-	-	-0.078 (0.925)	-0.078 (0.925)
Ethnicity (Ref=High Caste Hindu)				
Low Caste Hindu	-	-	-0.493 (0.611)*	-0.499 (0.607)*
Hill Tibetoburmese	-	-	-0.006 (0.994)	-0.006 (0.994)
Newar	-	-	-0.057 (0.945)	-0.056 (0.945)
Terai Tibetoburmese	-	-	-0.430 (0.650)+	-0.439 (0.645)+
Neighborhood characteristics				
No. of services within a 10-minute walk	-	-	0.253 (1.288)*	0.250 (1.285)*
Presence of Small Farmer Group (yes=1)	-	-	-0.733 (0.481)**	-0.731 (0.482)**
Proximity to urban center (Ref=strata 1)				
Strata 2 (between strata 1 and 3)	-	-	-0.384 (0.681)+	-0.365 (0.694)+
Strata 3 (farthest from the urban center)	-	-	0.176 (1.192)	0.204 (1.226)

Table 5.9 continued

Table 5.9 continued

Variables	Models			
	1	2	3	4
Used two or more items vs. None				
Intercept	1.093***	0.660	-5.685***	-5.463***
Demographic characteristics				
Number of working-age males/*hectare*	-0.510 (0.601)***	-0.522 (0.593)***	-0.301 (0.740)***	-0.504 (0.604)***
Number of working-age males/*hectare* squared	-	-	-	0.021 (1.022)*
Other				
Age of head of the household (years)	-	0.006 (1.006)	0.017 (1.017)	0.017 (1.017)
Migration of individual from household (yes=1)	-	0.790 (2.203)**	0.491 (1.635)+	0.561 (1.753)*
Socioeconomic characteristics				
Quality of land (Ref=*Bari* only)				
Khet only	-	-	1.493 (4.450)***	1.508 (4.517)***
Khet and *Bari* only	-	-	0.932 (2.538)*	0.935 (2.547)*
Land ownership (Ref= Sharecroppers)				
Full owners (yes=1)	-	-	1.828 (6.220)*	1.839 (6.292)*
Part-owners (yes=1)	-	-	1.097 (2.994)	1.102 (3.009)
Fragmentation of holding (no. of land parcels)	-	-	0.554 (1.741)***	0.551 (1.736)***
Livestock ownership (yes=1)	-	-	0.247 (1.281)	0.269 (1.309)
Education of head of the household (years)	-	-	0.106 (1.112)***	0.107 (1.113)***
Ownership of radio and television (yes=1)	-	-	0.751 (2.120)**	0.759 (2.136)**
Ethnicity (Ref=High Caste Hindu)				
Low Caste Hindu	-	-	-1.772 (0.170)**	-1.762 (0.172)**
Hill Tibetoburmese	-	-	-0.191 (0.826)	-0.201 (0.818)
Newar	-	-	0.008 (1.008)	-0.037 (0.963)
Terai Tibetoburmese	-	-	-0.798 (0.450)*	-0.789 (0.454)*
Neighborhood characteristics				
No. of services within a 10-minute walk	-	-	0.055 (1.056)	0.057 (1.059)
Presence of Small Farmer Group (yes=1)	-	-	-1.343 (0.261)***	-1.330 (0.265)***
Proximity to urban center (Ref=strata 1)				
Strata 2 (between strata 1 and 3)	-	-	0.202 (1.224)	0.175 (1.192)
Strata 3 (farthest from the urban center)	-	-	1.639 (5.149)***	1.590 (4.905)***
Chi-Square	150.385***	168.790***	326.079***	332.581***
-2 Log likelihood	676.661	1832.784	1819.828	1813.326
Degrees of freedom	2	6	38	40
McFadden Pseudo R-square	0.070	0.079	0.152	0.155

t-statistic *** = p<.001; ** = p<.01; * = p<.05; + = <.10 Figures in parentheses are odds ratios. 1 hectare = 1.5 *bigha* = 30 *kattha* effects of various factors between households that used two or more inputs versus those that used none of them.

First, I describe the effects of demographic characteristics on the use of bio-chemical and mechanical technological packages. Then, the following sections focus on the effects of socioeconomic and neighborhood characteristics on the use of both of these technological packages.

5.3.3.1. Demographic Characteristics and Bio-chemical Technology Use

The effects of various household-level demographic characteristics such as availability of family labor per unit of cultivated land, age of the household head and migration of individuals from the household on the use of bio-chemical technology are provided in Tables 5.4 to 5.6, respectively for total, female, and male labor. The results show that the increases in working-age family labor per hectare of cultivated land significantly decreases the likelihood of using bio-chemical inputs in crop production. For example, a one person increase in working-age family labor per hectare of cultivated land significantly decreased the odds of using any one item of bio-chemical input, chemical fertilizer or pesticide, by over 6 percent (odds ratio = 0.936; p<.001, model 1, top panel, Table 5.4). Similarly, a one person increase in family labor per hectare of cultivated land decreased the odds of using both of the items of bio-chemical inputs by about 10 percent (odds ratio = 0.903; p<.001; bottom panel). This independent variable, presence of working-age family labor per unit of cultivated land alone explained slightly over 3 percent of the variation (McFadden Pseudo R-square = 0.034) in the dependent variable bio-chemical technology use. The model also fits the data (Chi-square = 74.743; $p<.001$).

The magnitude of the effect remained the same when other household demographic characteristics such as the age of the household head and the migration of an individual from the household were included in the analysis (model 2). Moreover, these two additional demographic variables, the age of the household head and the migration of an individual from the household, however, did not contribute significantly to the use of bio-chemical technology. The effect of the household head on the use of bio-chemical inputs is consistent with the findings of the Fertilizer Study (Ministry of Agriculture and Cooperatives 2003). The results suggest that these variables were statistically not important for the adoption of chemical fertilizers and pesticides in agriculture.

The effect of the presence of working-age family members per unit of cultivated land slightly diminished after the inclusion of socioeconomic and neighborhood characteristics (model 5, top and bottom panel). The decrease in the magnitude of the effect of family labor availability was mediated particularly through number of land parcels and percentage of irrigated land, both of which positively contributed to the uses of bio-chemical inputs. It is mainly because the fragmentation of land into many parcels and the availability of irrigated land demand relatively more labor input compared to having fewer parcels and less irrigated land.

The effect of the squared-term of family labor availability on the uses of any one or both of the items of bio-chemical inputs was statistically not significant suggesting that the family labor availability has only a linear effect on the use of bio-chemical technologies (model 6, top and bottom panels, Table 5.4). This implies that the adoption of bio-chemical inputs does not change at a different rate with the change in the level of family labor availability per unit of land.

Gender and bio-chemical technology use. In developing countries, gender roles are important in agriculture, because some of the farming operations are gender specific (for example, Boserup 1970; Sachs 1996; Kumar and Hotchkiss 1988). For instance, application of farmyard manure, weeding, and thinning out of disease and insect infested plants are primarily carried out by women, although men also perform these activities (Pradhan 1981; Bhandari et al. 1996). Therefore, further analysis was done by disaggregating family labor by gender to examine whether the presence of male and female family members contribute differently to the use of bio-chemical technology in crop production.

The results of the effects of the presence of working-age female and male family members per hectare of cultivated land on the use of bio-chemical inputs are presented in Tables 5.5 and 5.6, respectively. The results from the initial models (models 1 and 2) indicated that one person increases in the availability of working-age female or male members per hectare of cultivated land significantly reduced the odds of using of any one (top panel) or both (bottom panel) items of bio-chemical inputs. For example, a one person increase in female laborer per hectare of cultivated land decreased the odds of using any one input by 12 percent (odds ratio = 0.879; $p<.001$; top panel; model 1; Table 5.5) and both inputs by 19 percent (odds ratio= 0.815; $p<.001$; bottom panel; model 1; Table 5.5). These results hold true after adjusting for the effects of other demographic characteristics (model 2; top and bottom panels). Similar results hold true for males (models 1 and 2, top and bottom panels, Table 5.6).

When other demographic, socioeconomic, and neighborhood characteristics were taken into account, the effects of female and male family labor were diminished (models 3; top and bottom panels; Tables 5.5 and 5.6, respectively). However, the effects of the squared-terms of the availability of female or male laborers were statistically not significant (model 4, top and bottom panels, Tables 5.5 and 5.6) suggesting that the use of bio-chemical inputs is linearly affected by the availability of female or male laborers in a household.

When both of these variables, number of working-age females and males per hectare of cultivated land were simultaneously included in the model, only the effect of females remained statistically significant for those who used both the items of bio-chemical input (models 5 and 6, Table 5.5). These results indicate that the availability of working-age female family labor is relatively more important in the decision to use more items of bio-chemical inputs than their male counterparts. This result is plausible because women are primarily engaged in weeding, thinning out of disease infested plants, and carrying and applying farmyard manure in the field (Bhandari et al. 1996). However, the effects of other demographic factors such as the age of the household head and migration of individual(s) from a household for work reason are statistically not important in the decision to use bio-chemical input in agriculture.

5.3.3.2. Demographic Characteristics and Mechanical Technology Use

The effects of household demographic characteristics on the use of mechanical inputs, pumpsets, farm implements and tractors are provided in Tables 5.7 through 5.9. As in bio-chemical technology use, increased availability of family labor per unit of cultivated land negatively influenced the use of mechanical inputs considered in this study. For example, overall, a one person increase in total family labor per hectare of cultivated land reduced the odds of using any one item of mechanical input by about 6 percent (odds ratio = 0.935; p<.001; model 1, top panel, Table 5.7), or two or more items of mechanical inputs by 28 percent (odds ratio = 0.724; p<.001; model 1, bottom panel; Table 5.7). The effects remain after taking into accounts of the effects of other demographic factors (model 2). Although the magnitude of the effect diminished, the independent effect remains after controlling for other socioeconomic and neighborhood characteristics (model 5, top and bottom panels). This finding is consistent with the hypothesis that increased family labor availability reduces the likelihood of using mechanical inputs in farming.

When I added the squared-term of labor availability, while the curvilinear effect is not statistically significant for those who used only one mechanical input, the linear effect remained (model 6, top panel). However, the curvilinear effect is important for using two or more items of mechanical inputs. The use of mechanical inputs diminishes with the availability of family labor, however, increases when there are many family laborers available per unit of cultivated land (model 6, bottom panel).

The age of the household head did not contribute significantly to the use of any one farm machine. But this variable contributed weakly but positively to the use of two or more mechanical inputs, when the effects of other demographic, socioeconomic and neighborhood contextual factors were controlled. For example, a 10-year increase in the age of the household head increased the use of two or more farm machines by 19 percent (odds ratio = 1.019; $p<.10$; model 5, bottom panel; Table 5.7).

It was expected that older household heads are not used to new farm technologies and therefore, would not use them in farming. However, the result indicates that the age of the household head slightly increased the odds of using two or more items of mechanical inputs use after adjusting for the effects of household socioeconomic and neighborhood characteristics (models 5 and 6; Table 5.7). One reason behind such a surprising result could be that the use of manual irrigation, hand threshing, and other farm activities that can be performed by using machines are relatively difficult and time consuming compared to the use of machines. For example, manual threshing of rice-paddy and wheat is a very difficult task and time consuming. It needs strong muscles to thrash the bundles on the ground so that all the grains can be separated out from the straw. Similarly, use of a corn sheller is much easier and time-saving than hand threshing of each and every corn cob, which is commonly practiced in Nepal. Older individuals may not be able to provide such labor, which might have motivated them to use pumpsets for irrigating fields and other farm implements such as threshers and corn shellers for other purposes. However, further study is needed to validate this explanation.

Migration of individual(s) from a household for work reasons also appeared to be important for using either one and two or more mechanical inputs. As expected, the odds of using any one farm machine increased by 71 percent (odds ratio = 1.711; $p<.01$; model 2, top panel; Table 5.7) when at least one member was away from home for work reasons net of other demographic characteristics. Similarly, households that had any member away from home for work reasons were over two-times more likely to use two or more farm machines in crop production than those households where no individual was away from home (odds ratio = 2.261; $p<.01$; model 2, bottom panel; Table 5.7). Although the magnitude of these effects slightly diminished, the statistical significance remained even after taking into account other demographic, socioeconomic and neighborhood characteristics in the analysis (models 5 and 6, Table 5.7) suggesting that migration of individuals has an independent and positive effect on the use of farm machines. Migration of individuals from a household, on the one hand, reduces the availability of family laborers (Muliana 2003), which might influence the use of labor-saving inputs in agriculture. On the other hand, the remittances received by the household from migrant member can be used to purchase required inputs.

Gender and mechanical technology use. These results also hold true when the household labor force is disaggregated by gender (Tables 5.8 and 5.9). Since the use of mechanical inputs was expected to replace male labor, the effect of male labor availability on mechanical technology use was expected to be relatively higher compared to females. However, interestingly, the magnitude of the effect of the female labor availability is marginally but consistently greater across all the models than the magnitude of the effect of male labor availability. Similarly, the explanatory power of the female models is also slightly greater compared to male models. Although the actual mechanism is not clear, this could be because women spend more time in household work including farming than men (FAO 2000; Kumar and Hotchkiss 1988; NESAC 1998) and replace men’s work wherever possible, for example, digging of crop fields, manual threshing and loosening of corn grains from ears instead of using machines (corn sheller), etc. For example, FAO (2000) reported that women spend 10.8 hours per day in agriculture compared to 7.5 hours per day for men. It is also relevant to mention the finding from India that "…mechanization in agriculture is found mainly in men's work. Women's work, (including household tasks) has remained predominantly manual" (Singh et al. 1992:279-280), which is also true in Nepalese agriculture.

In summary, the findings provide evidence that household demographic characteristics are important in the decision to use modern inputs in agriculture. The presence of working-age family members per unit of cultivated land negatively affects the use of labor-saving bio-chemical (chemical fertilizers and pesticides) and mechanical inputs (pumpsets, farm implements, and tractors) in the subsistence agricultural setting of Nepal where family labor is widely used in farming. A farm household prefers to use its farm resources by mobilizing its manual labor such as applying farmyard manure instead of purchased chemical fertilizers, and weeding and sorting out diseased plants, irrigating crop fields, plowing land or performing other agricultural operations such as threshing as long as family labor is available. Stated differently, labor-saving modern inputs are used by households only when there is a shortage of family labor. This finding provides evidence of family labor availability per unit of cultivated land as an important constraint behind the low or no use of modern inputs in Nepalese agriculture.

The results also indicated a curvilinear effect of labor availability in using two or more items of mechanical inputs. Household with a large number of working-age family members available per hectare of land were found to use more items of modern mechanical inputs. Although the mechanism behind such a relationship is not clear, one possible reason could be that these households might choose to use available land more intensively by using modern inputs so that they can increase food production per unit of land to feed more people in the household. Such households opt for cultivating labor-intensive crops such as vegetables and other high yielding varieties, which require relatively more labor input for their care and management. Moreover, these are the small farmers who farm their land more intensively to meet their subsistence needs (Schutjer and Van der Veen 1977; Van der Veen 1975). However, the lack of curvilinear effect on the use of bio-chemical inputs suggests for need of a further study to validate the finding.

Evidence also showed that the presence of both working-age men and women family members were important on the decisions to use bio-chemical and mechanical technologies. Nevertheless, the role of female labor was found to be relatively more important in the decision to use both bio-chemical and mechanical inputs compared to their male counterparts suggesting that less effort has been made to replace women's tasks with modern inputs than those of males. This finding provides evidence in support of the importance of women in farming, whose roles have been largely neglected thus far in Nepalese agriculture. The effect of the age of the household head on the uses of various farm technologies is not consistent, implying that older household heads are not an important obstacle to use of modern technologies in agriculture. Similarly, migration of individuals from a household for work reasons encouraged the use of labor-saving mechanical inputs in farming.

5.3.3.3. Socioeconomic Characteristics and Bio-Chemical Technology Use

The results of the effects of socioeconomic characteristics such as land ownership, land quality, land fragmentation, livestock ownership, education of household head, exposure to communication media, and ethnicity on the use of bio-chemical technologies are presented in Tables 5.4 to 5.6. Overall, socioeconomic characteristics explained over 10 percent (Pseudo R-square = 0.102) of the variation in the dependent variable bio-chemical technology use (model 3, Table 5.4) suggesting their important contribution to the adoption of chemical fertilizers and pesticides in farming. The model also fits the data (model Chi-square=169.975; $p<.001$).

Among socioeconomic characteristics, the number of land parcels, education of the head of household, and ethnicity significantly contributed to the use of bio-chemical inputs, chemical fertilizers and/or pesticides. Land fragmentation, the number of land parcels, and education of the household head positively influenced their use. For example, net of other socioeconomic factors, every unit increase in land parcels in a household increased the odds of using any one bio-chemical input by 87 percent (odds ratio = 1.869; $p<.001$; model 3; top panel, Table 5.4). Similarly, each additional land parcel increased the odds of using chemical fertilizers and pesticides by over two times (odds ratio = 2.054; $p<.001$; model 3; bottom panel, Table 5.4). Although the magnitude of the effect slightly diminished, the results are consistent when household demographic, other socioeconomic and neighborhood characteristics were controlled (models 5 and 6).

Increased numbers of cultivated land parcels that are scattered in different places were expected to hinder the use of improved farm inputs due to reduction in care and management of crop fields. ANZDEC Limited (2002) also indicated that scattered nature of farm parcels and their small size has hindered Nepalese farmers from using productivity enhancing technologies. The effect of land fragmentation on bio-chemical inputs use, however, was contrary to this expectation. There could be several reasons for this unexpected result. First, the average number of parcels of 2.18 may not be too high in the Chitwan Valley as compared to those in the Hills and high Hills. Or, it is also because the land parcels are scattered farther apart which creates difficulty in transporting and applying farmyard manure manually in the distant fields. Because "the involvement of long distances and hence the waste of time and effort that it entails for moving labor, animals, harvested crops, and the difficulties of supervision" affects agricultural intensification (Gebeyehu 1995:50).

Education of the household head was also important in the decision to use bio-chemical technology. For example, every one year increase in schooling of the head of a household increased the odds of using any one bio-chemical input by 5 percent (odds ratio = 1.050; $p<.05$; model 3; top panel, Table 5.4) net of other socioeconomic factors. Similarly, each additional year of schooling of the household head increased the odds of using both items of these bio-chemical inputs by 10 percent (odds ratio = 1.099; $p<.001$; model 3; bottom panel, Table 5.4). These effects remain after controlling for household demographic, socioeconomic, and neighborhood characteristics (models 5 and 6; Table 5.4). The exposure to communication media as measured by the ownership of radio and/or television in the household contributed weakly but positively to the use of both of the inputs, chemical fertilizers and pesticides.

Chemical fertilizers and pesticides use also varied by ethnicity. As compared to the households belonging to the High Caste Hindu (for example, Brahmin and Chhetri), the households belonging to other ethnic groups were relatively disadvantaged in using bio-chemical inputs. However, households belonging to the Low Caste Hindu (for example, Kami, Damai, Sunar also called *Dalit*) and the Terai Tibetoburmese groups (for example, Tharu, Kumal, and Darai) were significantly less likely to use these inputs (model 4), net of other socioeconomic characteristics. For instance, compared to the households of High Caste Hindu, while households belonging to the Low Caste Hindu were 63 percent (odds ratio = 0.369; p<.001; model 3; top panel, Table 5.4) less likely to use any one item of bio-chemical input, the households belonging to the Terai Tibetoburmese were 76 percent (odds ratio = 0.236; p<.001; model 3; top panel, Table 5.4) less likely to use it. Similarly, these households were 66 percent and 79 percent less likely to use both items of these inputs (model 3; bottom panel, Table 5.4)), respectively, compared with those belonging to the High Caste Hindu. These effects remained after taking into account of demographic, other socioeconomic and neighborhood characteristics (models 5 and 6, Table 5.4). However, the households belonging to other ethnic groups were not statistically different from the High Caste Hindu households.

5.3.3.4. Socioeconomic Characteristics and Mechanical Technology Use

Socioeconomic characteristics included in the analysis explained about 11 percent (adjusted R-square = 0.107) of the variation on the use of mechanical inputs such as tractors, pumpsets and farm implements (model 3, Table 5.7). Overall, land quality, land ownership, land fragmentation, education of the household head, exposure to communication media, and ethnicity contributed significantly to the use of these mechanical inputs in crop production. Although land quality, land ownership and ownership of radio and television were not significantly related to the adoption of one item of mechanical technology, all the factors listed earlier significantly contributed to the use of two or more items.

The type of cultivated land was used as an indicator of land quality. *Khet* land is considered high quality land compared to *bari* land and therefore, it was hypothesized that households cultivating only *khet* land should be more likely to use farm machines such as pumpsets for irrigation and tractors for land preparation. As hypothesized, the results show that households that cultivated only *khet* land, and *khet and bari* both were found to be more likely to use these mechanical inputs compared to those who cultivated only *bari* land. But the effects are statistically significant for those households who used two or more items of mechanical inputs net of other socioeconomic characteristics. For example, the households who cultivated only *khet* land were about five-times (odds ratio = 4.670; $p<.001$; model 3; bottom panel, Table 5.7) more likely to use two or more technology items than those who cultivated only *bari* land. Similarly, those who cultivated both *khet* and *bari* land were over four-times more likely to use two or more items of mechanical inputs (odds ratio = 4.146; $p<.001$; model 3; bottom panel, Table 5.4) net of other socioeconomic factors.

Despite a slight decrease in the magnitude of the effect of land quality, the statistical significance remained for those who cultivated only *khet* land, but the statistical difference was lost between those who cultivated *khet* and *bari* land and those who cultivated only *bari* land when other demographic, other socioeconomic and neighborhood factors were controlled (models 5 and 6, bottom panel, Table 5.7). The reduction in the magnitude and statistical significance was particularly associated with family labor availability. It is because households that cultivate *bari* land use manual labor in *bari* land and mechanical inputs in the *khet* land. Farm households with more *khet* land are relatively better-off farmers compared to those who cultivate only *bari* land. And households that cultivate only *bari* land are relatively subsistence in nature compared to those who own and cultivate *khet* land.

Land ownership also contributed to the use of mechanical inputs. Full owner farmers were significantly more likely to use two or more items of mechanical inputs than sharecroppers. However, full owners as well as part owners were significantly not different from the sharecroppers to use any one item.

Contrary to expectations, land fragmentation strongly and positively contributed to the use of these mechanical inputs as in the case of bio-chemical technologies. For example, a one unit increase in land parcel increased the odds of using any one item of farm machinery by 34 percent (odds ratio = 1.339; $p<.01$; model 3; top panel, Table 5.7) net of other socioeconomic characteristics. Similarly, each additional land parcel increased the odds of using two or more items of mechanical inputs by over 2 times (odds ratio = 2.210; $p<.001$; model 3; bottom panel, Table 5.4). Although the magnitude of the effect diminished when other demographic, socioeconomic and neighborhood factors were included in the analysis (models 5 and 6, Table 5.7), the statistical significance still remains providing evidence for its independent effect on mechanical inputs use.

As in bio-chemical technology use, education of the household head also contributed significantly to the use of mechanical inputs. Each additional year in schooling of the head of a household increased the likelihood of using either one or two or more items of mechanical inputs. The magnitude and the strength of the effect of education remained even after adjusting for the effects of other demographic, socioeconomic and neighborhood characteristics in the analysis. Similarly, ownership of radio and television, used as a measure of media exposure was statistically significant in the decision to use two or more items of mechanical inputs. By ethnicity, compared to households belonging to the High Caste Hindu, households belonging to the Low Caste Hindu and the Terai Tibetoburmese groups were found to be significantly less likely to use pumpsets, farm implements, and tractors.

In summary, the findings in this section provide evidence that socioeconomic characteristics are important in the decision to use mechanical inputs such as pumpsets, farm implements and tractors in crop production. Moreover, the findings also provide evidence in support of the expectation that High Caste Hindus are relatively privileged and Terai Tibetoburmese and Low Caste Hindus are disadvantaged in using these modern inputs. The households belonging to the Terai Tibetoburmese and Low Caste Hindus are less likely to use mechanical inputs compared to High Caste Hindus. Land quality, land ownership, land fragmentation, education, and exposure to communication media encouraged farmers to use various mechanical inputs, whereas belonging to ethnic groups other than High Caste Hindu discouraged the adoption of these inputs.

5.3.3.5. Neighborhood Characteristics and Technology Use

Availability of services such as banks, cooperatives, and bus services within a ten-minute walk, presence of the Small Farmers Development Program in the neighborhood, and the proximity of a farm household from the urban center of Narayanghat are considered as neighborhood characteristics. It is expected that nearness to the services and urban center and the presence of the Small Farmers Development Program would enhance the use of farm technologies.

Overall, community characteristics explained a very small amount of variation in the dependent variables, use of bio-chemical and mechanical technologies. The community characteristics explained only 2 percent (Pseudo R-square = 0.019) of the variation on the bio-chemical technology use, and about 2.4 percent (Pseudo R-square = 0.024) of the variation on the mechanical technology use. The models, however, fit the data in both cases (Tables 5.4 and 5.7).

Although the access to community services such as banks, cooperatives, and bus services within a 10-minute of walk did not contribute significantly to the use of any one or both items of bio-chemical items, the direction of the effect, however, was negative. But the effect of this variable on the use of both items of bio-chemical inputs turned out to be statistically significant when demographic and socioeconomic were included in the analysis (models 5 and 6, bottom panel, Table 5.4). For example, each additional service weakly but significantly reduced the odds of using both chemical fertilizers and pesticides by 27 percent net of demographic, socioeconomic and other neighborhood characteristics (odds ratio = 0.729; $p<.10$; model 5, bottom panel, Table 5.4), which was not expected. In contrast, each additional service increased the odds of using any one item of mechanical input by 33 percent (odds ratio = 1.328; $p<.01$; model 4; top panel, Table 5.7) net of other contextual factors and 29 percent (odds ratio = 1.293; $p<.05$; model 5; top panel, Table 5.7) net of demographic, socioeconomic and neighborhood factors. However, the effect was statistically not important for using two or more items of mechanical inputs (odds ratio = 1.067; $p>.10$; model 4; bottom panel, Table 5.7). These findings suggest that access to services does not seem to be a major factor limiting adoption of bio-chemical inputs in the Chitwan Valley of Nepal. But the access to various services seems important for the use of mechanical inputs.

Moreover, farm households in the community where the Small Farmer Development Program (SFDP) was implemented were found to be less likely to use both of bio-chemical and mechanical inputs particularly after controlling for the effects of strata, the location of households from the urban center of Narayanghat. One reason behind such a counterintuitive result could be due to the fact that such SFD programs are implemented in communities (strata 3) where most farmers are small and economically vulnerable. Membership of a household in the SFDP requires certain criteria (with less than 0.5 hectares of land) for group membership. Those households that do not qualify for membership do not receive benefits from the SFDP. These results are somewhat surprising.

The effect of proximity of households from the urban center on technology use is interesting. For instance, households living in areas away from the main market center of Narayanghat, particularly living in the second strata are significantly less likely to use any one bio-chemical technology as compared to those that are living in the vicinity of urban center (odds ratio = 0.387; $p<.001$; model 4; top panel, Table 5.4). This result is consistent with the hypothesis. However, contrary to expectations, farmers who lived in remote areas were found to be more likely to use bio-chemical inputs compared to those who are in or close to the urban center. The difference between these two groups of farmers is statistically significant when demographic, socioeconomic and other neighborhood characteristics were controlled in the analysis. This result is consistent with the finding of the Fertilizer Use Study recently conducted in Nepal that "the access to markets is not an important factor in the decision of households to use fertilizers" (Ministry of Agriculture and Cooperatives 2003:32).

On the other hand, households living in rural areas are found to be indifferent in using any one item of mechanical input than those who are living close to the urban center. On the other hand, the likelihood of using two or more mechanical inputs increased for farmers who lived in remote areas compared to those who lived in the urban center. This counterintuitive result could be due to the differential size of land. The average size of land is larger in areas further away from the urban center, which might be suitable for using tractors. For example, the average size of land in strata 3 (farthest from the urban center) is 29.36 *kattha,* which is followed by 22.68 *katha* in strata 2 (in between strata 1 and 3) and 19.10 *kattha* in strata 1 (close to urban center). Moreover, households farther away from the urban center may be less likely to receive canal water on time as these households reside in the tail end of both the Khageri and the Narayani Irrigation systems, the two large irrigation systems developed by the government. This might have motivated farmers to use pumpsets for irrigating their fields. The findings, however, do not provide a clear rural-urban difference on the use of mechanical inputs.

In summary, the access to community services such as banks, cooperatives, bus services, Small Farmers Development Program, and proximity of farm household from the urban center neither explain much of the variation in the dependent variables, nor do they have a consistent effect on the use of bio-chemical as well as mechanical technologies. It was expected that lower access to services in the community, unavailability of community development services such as the SFDP, and rural location of households would reduce the likelihood of adopting modern inputs. Development of these services is a major concern of the Nepalese government (APP 1995; NPC 2003) as these services are supposed to facilitate adequate and timely distribution of farm inputs. However, based on the findings of this study, the assumption of inadequate and untimely distribution of inputs affecting non-adoption of modern inputs does not seem true at least in the context of western Chitwan Valley.

5.4. Summary

A summary of the findings is presented in Table 5.10. The purpose of this chapter was to examine the effect of family labor availability per unit of cultivated land on the use of labor-saving bio-chemical technologies such as chemical fertilizers and pesticides, and mechanical technologies such as tractors, pumpsets and farm implements in the Chitwan Valley of Nepal. This chapter also examined the effects of other household demographic characteristics such as the age of the household head and migration of individuals from the household, socioeconomic characteristics such as land ownership, land quality, exposure to communication media and education, and neighborhood characteristics such as access to community services and rural-urban location of households on the use of modern inputs.

The findings provide evidence that the availability of working-age family members per unit of cultivated land decreases the likelihood of using modern labor-saving bio-chemical and mechanical inputs in a subsistence agricultural setting of Nepal, where family labor is widely used in performing various agricultural operations such as applying farmyard manure in the field, weeding, plowing, and irrigating crop fields.

Moreover, the presence of working-age women is important in the decision to not adopt both of these modern inputs. This finding provides an important explanation for the limited adoption of modern inputs by farm households, despite several decades of governmental efforts. The role of human resources, particularly the availability of family labor on agricultural modernization, however, has not been emphasized by the APP (ANZDEC Ltd. 2000), as well as the current agricultural development plans of Nepal. Moreover, as a common belief that older individuals are less likely to use modern inputs in agriculture, this study provides evidence that the age of the household head is not an important obstacle in the adoption of different kinds of modern inputs.

This study also provides evidence that household socioeconomic factors are important in the decision to adopt modern farm inputs. Land fragmentation, education of household head and land ownership increased the adoption of both bio-chemical and mechanical inputs in the Chitwan Valley. Technology use also differed by ethnicity. Households that belonged to the Terai Tibetoburmese and Low Caste Hindu are found to be significantly less likely to use both technologies as compared with High Caste Hindu households. However, the effects of other factors differed by type of farm technology used. For example, the exposure to communication media was important for the use of mechanical inputs, but was not a significant contributor to the use of bio-chemical inputs. From a policy perspective, these findings suggest providing differential attention to encourage farmers to use modern farm inputs.

Table 5.10. Summary of Multivariate Results

Variables	Technology Packages			
	Bio-chemical		Mechanical	
	Any one item vs. None	Both items vs. None	Any one item vs. None	Two or more items vs. None
Demographic characteristics				
No. of working-age males and females/hectare	Negative	Negative	Negative+	Negative***
No. of working-age males-females/hectare squared	Negative	Positive	Positive	Positive***
No. of working-age females/hectare[1]	Negative+	Negative*	Negative	Negative***
No. of working-age females/hectare squared[1]	Positive	Positive	Negative	Positive***
No. of working-age males/hectare[1]	Negative	Positive	Negative	Negative***
No. of working-age males/hectare squared[1]	Negative	Negative	Negative	Positive*
Age of head of the household (years)	Positive	Positive	Negative	Positive+
Migration of individual from household (yes = 1)	Negative	Negative	Positive*	Positive*
Socioeconomic characteristics				
Quality of cultivated land: *Bari* only (yes = 1)				
Khet only (yes = 1)	na	na	Positive	Positive**
Khet and *Bari* both (yes = 1)	na	na	Negative	Positive
Irrigated land (percent)	Positive	Positive	na	na
Land ownership: Sharecroppers (yes = 1)				
Full owners (yes = 1)	Positive	Positive*	Positive	Positive*
Part-owners (yes = 1)	Negative	Positive	Positive	Positive
Fragmentation of holding (number of land parcels)	Positive***	Positive***	Positive*	Positive***
Livestock ownership (yes = 1)	Positive	Negative	Positive	Positive
Education of head of the household (years)	Positive+	Positive***	Positive+	Positive**
Ownership of radio and television (yes = 1)	Positive	Positive	Negative	Positive**
Ethnicity (Ref = High Caste Hindu)				
Low Caste Hindu	Negative**	Negative*	Negative+	Negative**
Hill Tibetoburmese	Negative	Negative	Negative	Negative
Newar	Positive	Negative	Negative	Positive
Terai Tibetoburmese	Negative***	Negative***	Negative	Negative+
Neighborhood characteristics				
No. of services within a 10-minute walk	Negative	Negative+	Positive*	Positive+
Presence of small farmer group (yes = 1)	Negative	Negative+	Negative**	Negative***
Proximity to urban center: (Ref = strata 1)				
Strata 2 (between strata 1 and 3)	Negative***	Negative	Negative+	Positive
Strata 3 (farthest from the urban center)	Positive+	Positive+	Positive	Positive***

*** = p<.001; ** = p<.01; * = p<.05; + = <.10 na = not applicable
1 hectare = 1.5 bigha = 30 *kattha*
Results are based on model 6 of Tables 5.4 to 5.7.
[1]Results based on model 4 of Tables 5.5, 5.6, 5.8 and 5.9.

Access to community services contributed differently to the use of bio-chemical and mechanical technologies. For instance, while increased access to services in the community increased the likelihood of using mechanical inputs, this decreased the likelihood of using fertilizers and pesticides. Similarly, the presence of community development program, SFD, also did not add to the adoption of various inputs. Moreover, interestingly, the farmers living in remote areas were more likely to use these inputs than those living in the vicinity of the urban area. Although the belief is that no or low use of modern inputs is primarily due to their inadequate and untimely supply (APP 1995; Chapagain 2001; ANZDEC Limited 2002; NPC 2003), these inconsistent findings suggest that inadequate supply of farm inputs does not seem to be a major factor limiting the adoption of modern inputs at least in this setting of the western Chitwan Valley of Nepal.

CHAPTER 6

OCCUPATIONAL MOBILITY OF FARM HOUSEHOLDS

6.1. Introduction

The shift of occupation[1] from farming to non-farming activities is a recent phenomenon in Nepal, in general, and the western Chitwan Valley, in particular. This chapter explores various household-level demographic, socioeconomic, and neighborhood characteristics that influence occupational shift or transition of farming households to non-farming activities. As described in Chapter 1, out of the total of 1,269 households that were farming in 1996, a total of 1,216 households were resurveyed in 2001. Other households could not be contacted due to various reasons such as out-migration, merging into a different household and demise of household member in a single member family unit. Of these 1,216 farming households resurveyed in 2001, 7.5 percent (n = 91) of them had left farming occupation by 2001. These households did not farm even during the main crop cultivation season of the year, i.e., the rainy season or main rice planting season and therefore, they are considered as permanent exits.

The important question here is–what types of households exit farming? Understanding of this issue is important in the Nepalese context because increasing pressure of population in agriculture has been considered one of the important problems facing the country (Ashby and Pachico 1987), which has contributed to low agricultural productivity due to increased marginal land under cultivation (Chitrakar 1990; Karan and

[1] In this study, the terms occupational mobility, occupational transition, occupational shift, occupational change and farm exit are used interchangeably.

Ishii 1996). Therefore, lessening the pressure of population in agriculture by diverting farm based individuals toward non-farm activities such as formal and informal sector jobs, tourism, and business has been the development agenda of the Nepalese government (NPC 1998; NPC 2003a).

A number of studies exist in developed countries that examine possible reasons for farm exit (for example, Goetz and Debertin 2001; Foltz 2004 in US; Kimhi and Bollman 1999 in Canada and Israel; Glauben, Tietje and Weiss 2003 in Germany; Stiglbauer and Weiss 2000 in Austria; and Pietola et al. 2002; Vare and Heshmati 2004 in Finland). While most of these studies focused on economic forces such as government payments, off-farm employment, land size, ownership, types of farm enterprises, and rural-urban location of households as factors contributing to farm exit, a few of them examined the influence of operator’s age as an important demographic characteristic. Stiglbauer and Weiss (2000) have also focused on the effects of other demographic characteristics such as operator’s marital status, gender, his/her family size and number of children as possible influences on farm exits.

In Nepal, the population census records occupation of individuals such as agricultural, professional and technical, services, administrative and others (CBS 1995). A comparison is also made between censuses whether the proportion of individuals in a particular occupation category has increased or decreased overtime. However, the information on who and why they either continue or change their occupations is not reported and such studies are virtually non-existent. This study adds to the current literature by empirically examining the effects of various household-level demographic, socioeconomic and neighborhood factors affecting a household’s movement out of farming to non-farm activities in Nepal, particularly focusing on the western Chitwan Valley.

There could be several possible routes out of farming. From a demographic perspective, family labor availability, household composition, and age of the household head may be important influences on farm exit decisions. Family labor is one of the most important resources in subsistence agriculture. Any shortage of family labor could have a significant effect on moving households out of farming. For example, according to Kimhi and Bollman (1999), the heads of larger families were less likely to exit in Israel. Moreover, since more women than men are engaged in farming in Nepal, and women spend more hours in the farm work than men (ANZDEC Limited 2002), the availability of female labor force in a household should have a strong and a negative effect on occupational transitions.

In farming communities, the household head is an important person to make crucial decisions. Since older individuals have extensive experience with the farm occupation, a household with elderly heads may be less likely to exit farming. On the other hand, younger individuals are more likely to change occupation (Moore 1966; Ogena and De Jong 1999) and they prefer non-farm work more than older individuals (Mahesh 2002). It is also possible that older individuals cannot work on the farm and, therefore, could be more likely to shift occupation toward non-farm activities. For example, in Canada, Kimhi and Bollman (1999) reported that age decreases the exit tendency at younger ages and increases it at older ages. However, this scenario is more likely if there is a government retirement plan for the farmers, which does not exist in Nepal.

Obviously, size of cultivated land is one of the basic resources for farming. Access to cultivated land provides both employment and income to a farm household. Therefore, limited access to cultivated land may have an important effect on the occupational transition of a farm household. Empirical evidence suggests that an increase in average farm size reduces the likelihood of farm exit (Glauben, Tietje and Weiss 2003; Pietola et al. 2002; Goetz and Debertin 2001; Kimhi and Bollman 1999).

Ownership of land and livestock are expected to discourage a household's occupation shift to non-farm activities because these resources result in greater attachment to farming. Ownership of land and livestock also provide employment and income to family members. Animals also help crop production by providing manure and draft power as crops and livestock are closely integrated in the Nepalese farming system. Therefore, a household with land and livestock should be less likely to move out of farming. Goetz and Debertin (2001) reported that US farmers are less likely to quit if they operate their own farm. Kimhi and Bollman (1999) also reported a similar tendency among farm owners in Canada.

Educated family members may prefer to work in the off-farm sector due to the relatively higher income compared to farming. Therefore, education of the household head is expected to encourage occupational shifts toward non-farm activities. In addition, the shift from farm occupation is expected to vary by ethnicity in Nepal, because some ethnic groups such as Terai Tibetoburmese (for example, Tharu, Kumal, Darai) are relatively more attached to the farm occupation than others. Similarly, farmers may obtain better returns from agriculture by adopting modern farm technologies, which may reduce the likelihood of their occupational shifts. Non-adopter farmers cannot compete with the adopters and therefore, are forced out of agriculture in the long run (Buttel et al. 1990; Shrestha 1990).

Presence of community services such as banks, cooperatives, employment opportunities, health services, schools and bus services in the neighborhood may provide non-farm employment opportunities and therefore, are expected to encourage occupational shifts of farm households. Similarly, communities with a greater proportion of non-farm households may demand various community services. Availability of non-farm employment opportunities may encourage households to leave farm occupations. Similarly, if some communities experience a natural shock such as loss of land due to flooding, the households in such communities may be discouraged to continue farming. Moreover, since farming is basically a rural occupation, rural-urban differences in occupational change are also expected. Goetz and Debertin (2001) found that farmers were likely to quit if they live in counties with high population densities or in metropolitan areas.

6.2. Unit of Analysis

The unit of analysis is (a) a household, (b) living inside the CVFS defined neighborhood boundary in 1996, (c) was farming at the time of survey in 1996, (d) is or is not living inside the neighborhood in 2001, and (e) is or is not farming at the time of 2001 survey. This definition leaves a total of 1,216 households. However, some of the variables used in this study such as age and education of the head of the households come from the individual-level data. As mentioned elsewhere in this study, the individual-level information was collected from fewer households because of individuals' eligibility criteria. Exclusion of those households leaves a sample of 1,180 households. Of these households, a total of 1,100 (92.3 percent) households continued farming, whereas 80 (7.7 percent) households left farming by 2001.

6.3. Analytic Strategy

First, I compared the demographic, socioeconomic and neighborhood characteristics of households that continued farming and those that left farming by 2001 using means and percentages. When appropriate, the results of one-way ANOVA are also discussed. Then, I used Pearson correlations to examine the association between dependent and independent variables and to diagnose any multicollinearity problems. Logistic regression technique was used as a multivariate tool, since the dependent variable occupation change is a dichotomy, coded "1" if a household changed its occupation from farming to non-farming, and "0" if a household continued farming occupation.

I examined the effects of household demographic factors such as the number of working-age females and males, numbers of children, presence of elderly members, and the age of the household head on occupation transition. These results are presented in model 1 of Table 6.2. In model 2, I provide the results of the effects of household-level socioeconomic factors such as access to cultivated land, land ownership, livestock ownership, ethnicity, and education of the household head. In model 3, I examine the effects of neighborhood contextual factors such as the proportion of non-farm households in the community, availability of services, the presence of the Small Farmer Development Program, and the proximity of households from the urban center of Narayanghat. Finally, in model 4, I included all the variables used in models 1 through 3 to examine their net effects.

6.4. Results and Discussion

6.4.1. Descriptive Results

Table 6.1 provides the results of the descriptive statistics such as mean, standard deviation (SD), range (minimum and maximum) or percentage of the households that changed farming occupation to non-farming activities and those that continued farming by 2001. The information among the household demographic characteristics discussed are number of working-age (15-64 years) women and men, number of children less than 6 years and between 6 and 14 years of age (working-age children), presence of elderly members over 64 years of age, and the age of the household head reported at the time of survey in 1996.

The average household size among those that continued farming is significantly larger compared to those who left farming in terms of the number of working-age women (1.76 vs. 1.40) and men (1.70 vs. 1.35), number of working-age children (1.43 vs. 0.96), and the age of the household head (42.24 years vs. 38.14 years). Although the average number of elderly members and the number of children below 6 years of age is greater for the households that continued farming, the differences are not statistically significant. The heads of the households who left farming are relatively younger.

The cultivated size of land is significantly larger for households that continued farming than those that left farming. Households that continued farming have, on average, about 26 *kattha* (0.87 hectare) of land, whereas those who left farming have about 12 *kattha* (0.40 hectare) of land, less than half a hectare of land. By land ownership, 83 percent of those households that left farming fully owned either *bari* or *khet* land in 1996 compared to 71 percent of those who continued farming. However, 13 percent of the households that left farming in 2001 are sharecroppers as against only 7 percent of those who continued farming. Livestock ownership also varied by farming status. About 93 percent of the households that continued farming owned livestock compared to 69 percent of those that left farming. Only a small difference was observed by ethnicity, which was not statistically significant (Chi-square distribution not shown).

The level of education of the household heads that left farming (4.83 years) was slightly higher but it was not statistically different from those who continued farming (4.18 years). A larger proportion of the households that continued farming used both bio-chemical (86 percent vs. 71 percent) and mechanical (80 percent vs. 66 percent) inputs in crop production.

Table 6.1. Descriptive Statistics: Demographic, Socioeconomic, and Neighborhood Characteristics by Household Farming Status (N = 1,180)

Variables[1]	Farming Status					
	Left Farming by 2001 (n = 80)			Continued Farming by 2001 (n = 1,100)		
	Mean[2]	SD	Range	Mean	SD	Range
Demographic characteristics						
Number of working-age females	1.40***	0.67	0-4	1.76	0.97	0-10
Number of working-age males	1.35**	0.78	0-4	1.70	1.01	0-8
Number of elderly persons (>64 years)	0.23	0.53	0-2	0.24	0.52	0-2
Number of children (<6 years)	0.71	0.90	0-4	0.75	0.95	0-5
Number of children (6-14 years)	0.96***	1.18	0-5	1.43	1.24	0-7
Age of household head	38.14**	13.31	15-80	42.24	12.32	15-78
Socioeconomic characteristics						
Size of cultivated land (*kattha*)	11.74***	12.59	1-67	26.18	23.62	1-200
Land ownership						
Full-owners	0.83*	0.38	0-1	0.71	0.45	0-1
Part-owners	0.05***	0.22	0-1	0.22	0.41	0-1
Sharecroppers	0.13+	0.33	0-1	0.07	0.26	0-1
Livestock ownership (owned = 1)	0.69***	0.47	0-1	0.93	0.26	0-1
Education of household head (years)	4.83	5.17	0-16	4.18	4.50	0-16
Ethnicity						
High Caste Hindu	0.41	0.50	0-1	0.49	0.50	0-1
Low Caste Hindu	0.13	0.33	0-1	0.11	0.31	0-1
Hill Tibetoburmese	0.24*	0.43	0-1	0.15	0.36	0-1
Newar	0.03	0.16	0-1	0.06	0.24	0-1
Terai Tibetoburmese	0.19	0.39	0-1	0.18	0.39	0-1
Technology use in agriculture						
Bio-chemical: Used any (=1)	0.71***	0.46	0-1	0.86	0.35	0-1
Mechanical: Used any (=1)	0.66**	0.48	0-1	0.80	0.40	0-1
Neighborhood (NBH) characteristics						
Non-farm households in the NBH (percent)	23.09***	24.87	0-91.67	10.30	12.69	0-89.47
Household in flooded NBH (yes=1)	0.01	0.11	0-1	0.03	0.17	0-1
No. of services within a 10-minute walk	2.78***	1.74	0-6	2.19	1.44	0-6
Presence of SF Program (yes = 1)	0.13+	0.33	0-1	0.20	0.40	0-1
Proximity to urban center (Ref = strata 1)	0.26	0.44	0-1	0.23	0.42	0-1
Strata 2 (between strata 1 and 3)	0.45*	0.50	0-1	0.32	0.47	0-1
Strata 3 (farthest from the urban center)	0.29**	0.46	0-1	0.45	0.50	0-1

[1]Data collected in 1996

[2]One-way ANOVA F test *** = p<.001; ** = p<.01; * = p<.05; + = <.10

1 hectare = 1.5 *bigha* = 30 *kattha*

Households that remained in farming had a smaller proportion of households engaged in non-farm activities (10.30 percent vs. 23.09 percent) and had fewer services available (2.19 vs. 2.78 services) in their neighborhood compared to those who left farming. One-fifth of households that continued farming were living in the neighborhoods where at least one member of the small farmers' development program was present compared to only 13 percent of households that left farming. By proximity to urban center, among those who changed farming, 26 percent of households were living in areas closest to the main market center of Narayanghat (strata 1), followed by 29 percent in areas farthest from the main market center (strata 3) and 45 percent in between these two areas. On the other hand, while slightly over 4 percent of households living in areas farthest from the main market center of Narayanghat changed farming, about 8 percent of those living in the vicinity of main market center (strata 1) changed their occupations (results not shown). Interestingly and surprisingly, the highest proportion of households (9.4 percent) living in strata 2 changed their occupation to non-farm activities.

6.4.2. Bivariate and Multivariate Results

Table 6.2 provides the results of bivariate and multivariate statistics. The bivariate results indicate that all the demographic characteristics included in the analysis are negatively associated with occupational change. These results imply that the greater the number of individuals in a household, the less the chance of occupation change. However, the relationship is statistically significant for the number of working-age females, the number of working-age males, and the number of working-age children. It suggests that the presence of working-age individuals in a household is important to continue farming occupation. The association is not statistically significant for the presence of elderly members and children below six years of age, however. The age of the head of the household is statistically significantly and negatively ($r = -0.083$; $p<.01$) associated with the change in occupation indicating that households with younger heads are more likely to exit farm occupation.

The bivariate association between the total cultivated size of holding and occupation change is significant and negative ($r = -0.156$; $p<.001$). The association between land ownership categories and occupation change, however, provides somewhat surprising results. Full land ownership is significantly and positively associated with occupation change ($r = 0.064$; $p<.05$), which was not expected. However, the association between occupation transition and sharecropping status is positive, and interestingly, part-ownership (owners plus sharecroppers) is significantly and negatively associated with occupation change. As expected, livestock ownership is negatively associated with farm exit ($r = 0.208$; $p<.001$). The association between occupation change and education of the household head is positive but not statistically significant. Ethnicity is not significantly related to farm exit. The bivariate association between farm exit and modern inputs use (both bio-chemical and mechanical technology) is negative and statistically significant.

The proportion of non-farm households in a community is strongly and positively associated with farm exit ($r = 0.226$; $p<.001$). Similarly, residence in a neighborhood where relatively more community services are available within a 10-minute walk is also positively and significantly associated with occupation transition ($r = 0.100$; $p<.001$). Living in a neighborhood where the small farmers' development program is located is negatively associated with farm exit. Moreover, rural residence of a household is negatively associated with occupation change except for those living in strata 2.

Pearson correlation coefficients used as an indicator of multicollinearity diagnostics indicate that none of the relationships among independent variables can be regarded as highly collinear. The correlation coefficients are well below 0.40 in most cases and between 0.40 and 0.50 only for a few cases. When the tolerance statistics provided in the OLS regression output of the SPSS program is examined, all the coefficients are above 0.38 (as against the bench mark of 0.20 used in this study) suggesting no serious collinearity problem in the data.

The results of bivariate correlation discussed thus far suggest the magnitude and direction of associations but not their net effects. Therefore, the results of the multivariate analysis are discussed below.

6.4.2.1. Demographic Characteristics and Occupational Mobility

Model 1 of Table 6.2 presents the odds ratio estimates for predicting the effects of various household-level demographic factors such as the availability of working-age labor, presence of children, presence of elderly persons and the age of the household head on the odds of occupation change of a household from farming to non-farming activity. About 6 percent (Pseudo R-square = 5.74 percent) of the variation in occupation transition has been explained by these demographic characteristics.

Overall, each unit increase in the number of persons belonging to each category of the life cycle in a household decreases the odds of an occupation transition. Specifically, a one person increase in the number of working-age (15-64 years) women lowers the odds of farm exit by 27 percent (odds ratio = 0.727; p<.10) adjusting for the effects of the numbers of working-age males, number of children, presence of elderly members in a household and the age of household head. Similarly, a one person increase in working-age (15-64 years) men in a household also significantly decreases the odds of changing farming to non-farming occupations by about 29 percent (odds ratio = 0.708; $p<.05$), net of other demographic factors. Moreover, the effect of the presence of working-age children (6 to 14 years) is also significant (odds ratio = 0.716; $p<.001$). The age of the household head (odds ratio = 0.923; $p>.10$), the curvilinear effect of the age of the household head (odds ratio = 1.001; $p>.10$), the presence of elderly members (odds ratio = 0.845; $p>.10$) and the number of younger children of age below 6 years (odds ratio = 0.889; $p>.10$) in a household did not contribute significantly to farm exit. The results suggest that the availability of working-age adults in a household is important to continue farming in the Chitwan Valley.

When other socioeconomic and neighborhood characteristics are added in the analysis, the statistical significance of the effects of working-age men and women is suppressed. This suggests that the effects of these variables, particularly the presence of female and male labor force, were mediated either by the cultivated land size and/or by livestock ownership. When I added these two variables, land holding and livestock ownership together or separately without the inclusion of other socioeconomic variables (results not shown), the effects of working-age males and females were suppressed and turned out to be statistically non-significant. While the significance of their effects remain unchanged when other socioeconomic and neighborhood context variables are added in the analysis in absence of the cultivated land size and livestock ownership. This is due to the fact that the size of cultivated land and livestock ownership demand significant amounts of labor and therefore, the effect of working-age labor might have been mediated through these variables. The effect of the presence of elderly members changed to positive when all other factors are controlled. However, the effect is not statistically significant.

The effect of number of children between 6 to 14 years, however, remains statistically significant when socioeconomic and neighborhood contextual factors were included in the analysis (model 4). The findings suggest that the presence of working-age children has an independent effect (odds ratio = 0.744; $p<.05$, model 4) on farm exit.

There could be several reasons behind the independent and negative effect of the number of working-age children on occupation change from farming to non-farming activities. Obviously, the number of children in a household means there is a potential supply of child workers (Groothart and Kanbur 1995). It is widely recognized that children provide support to their parents in a variety of productive (for example, farm and off-farm work) as well as enabling (for example, meal preparation and child care) household activities (Kumar and Hotchkiss 1988; Skoufias 1994). They work in the fields and care for livestock (FAO 1986). In Nepal, children share a major portion of the household work burden (NPC and UNICEF/Nepal 1996). For instance, while boys under 14 perform activities such as farming, livestock grazing, and collecting firewood and fodder, after 14 years they take the full responsibility of adult males such as plowing,

Table 6.2. Bivariate Correlations and Logistic Regression Models for Predicting Occupational Mobility of Farm Households by Demographic, Socioeconomic and Neighborhood Characteristics (N = 1,180)

Variables	Bivariate Correlation	Multivariate Models			
		1	2	3	4
Demographic characteristics					
Number of working-age females	-0.094***	-0.318 (0.727)+	-	-	-0.108 (0.898)
Number of working-age males	-0.089**	-0.346 (0.708)*	-	-	-0.264 (0.768)
Number of children (<6 years)	-0.011	-0.118 (0.889)	-	-	-0.053 (0.948)
No. of working-age children (6-14 years)	-0.094***	-0.334 (0.716)**	-	-	-0.296 (0.744)*
Number of elderly persons (>64 years)	-0.007	-0.168 (0.845)	-	-	0.108 (1.114)
Age of the household head (years)	-0.083**	-0.080 (0.923)	-	-	-0.061 (0.941)
Age of the household head squared	-0.070*	0.001 (1.001)	-	-	0.001 (1.001)
Socioeconomic characteristics					
Size of cultivated land (*kattha*)	-0.156***	-	-0.042 (0.959)***	-	-0.038 (0.962)**
Land ownership: (Ref = Full owners)	0.064*				
Sharecroppers	0.052+	-	0.067 (1.069)	-	-0.149 (0.862)
Owners plus sharecroppers	-0.104***	-	-0.964 (0.382)+	-	-0.774 (0.461)
Any livestock (yes = 1)	-0.208***	-	-1.183 (0.306)***	-	-0.720 (0.487)*
Education of household head (years)	0.037	-	0.069 (1.072)*	-	0.030 (1.030)
Ethnicity: (Ref = Terai Tibetoburmese)	0.003				
High Caste Hindu	-0.041	-	0.113 (1.120)	-	0.010 (1.010)
Low Caste Hindu	0.014	-	0.050 (1.052)	-	-0.026 (0.975)
Hill Tibetoburmese	0.058*	-	0.447 (1.562)	-	0.151 (1.163)
Newar	-0.038	-	-0.908 (0.403)	-	-1.227 (0.293)
Technology use in agriculture					
Bio-chemical technology: Used any (=1)	-0.104***	-	-0.610 (0.543)*	-	-0.393 (0.675)
Mechanical technology: Used any (=1)	-0.088**	-	-0.286 (0.752)	-	-0.334 (0.716)

Table 6.2 continued

Table 6.2 continued

Variables	Bivariate Correlation	Multivariate Models 1	2	3	4
Neighborhood characteristics					
Non-farm households in the neighborhood (percent)	0.226***	-	-	0.040 (1.041)***	0.043 (1.044)***
Household in flooded neighborhood (yes=1)	-0.025	-	-	-0.092 (0.912)	0.108 (1.114)
No. of services within a 10-minute walk	0.100***	-	-	-0.001 (0.999)	-0.022 (0.978)
Presence of Small Farmer Program (yes=1)	-0.050+	-	-	-0.073 (0.930)	0.051 (1.052)
Proximity to urban center (Ref = strata 1)	0.019				
Strata 2 (between strata 1 and 3)	0.073*	-	-	0.573 (1.773)+	0.600 (1.823)+
Strata 3 (farthest from urban center)	-0.093**	-	-	-0.077 (0.926)	0.167 (1.182)
Intercept		0.788	-0.532	-3.419***	0.568
Model Chi-square		33.589***	84.520***	49.439***	127.616***
Degrees of freedom		7	11	6	24
-2LL		551.459	500.528	535.609	457.433
Pseudo R-square (percent)		5.74	14.45	8.45	21.81

Wald Chi-square *** = p<.001; ** = p<.01; * = p<.05; + = <.10 1 hectare = 1.5 *bigha* = 30 *kattha* digging and chopping logs. Similarly, girls perform activities such as fetching water, cleaning, washing clothes, and caring for younger children.

In an agricultural setting, Rosenzweig (1977:124) pointed out two important roles of children- “as durable commodities which yield psychic income and productive laborers…” This is one of the reasons for high demand for children among agricultural households. The demand for their labor in agriculture increases the demand for them as expected by the land-labor demand hypothesis (Stokes 1995; Stokes and Schutjer 1984; Stokes et al. 1986). As a result, there could be many children in a household that are supposed to help their parents in farming. Further, changes in occupation may not provide adequate employment for these children and other members of a household. Therefore, a household may not desire to leave farming.

Other reasons could be that these are school-age children and these children continue school as well as support their parents in the farm, which is commonly practiced in the Valley. For instance, FAO (1986:26) notes that working-age children who attend school “work on the farm from sunrise until they go to school and after school again in the evening.” This situation is true among farming communities in Nepal. Farm occupation also provides income needed for schooling of children. However, which of these reasons might have strongly affected the occupational transition decision of farm households needs further study.

6.4.2.2. Socioeconomic Characteristics and Occupational Mobility

The effects of household socioeconomic characteristics on the odds of household occupation transition are presented in model 2 (Table 6.2). The results indicate that the size of cultivated land, livestock ownership, and education of the household head appeared to be the significant contributors to household occupation shifts controlling for other variables in the analysis. Overall, inclusion of the socioeconomic characteristics explained over 14 percent (Pseudo R-square = 14.49) of the variation in the dependent variable signifying the important contribution of these variables on occupation change. The socioeconomic model also best fits the data.

Net of other socioeconomic characteristics, a one *kattha* increase in cultivated land significantly decreased the odds of shifting occupation from farming to non-farming activities by over 4 percent (odds ratio = 0.959; $p<.001$). Similarly, farm households that owned livestock such as cattle, buffalo, sheep and goats are over 69 percent less likely to change their occupation compared to those that did not own any livestock (odds ratio = 0.306; $p<.001$, model 2) controlling for the effects of other socioeconomic characteristics. These results remain even after controlling for the effects of demographic and neighborhood contextual factors suggesting their independent effects on farm exit decisions (model 4).

Ownership of land, however, did not show a household's strong commitment to continue farming. For example, adjusting for the effects of other socioeconomic characteristics, these results are not statistically significant indicating that there is no difference in occupational change between full owners and sharecroppers. It should be noted that full owners possessed relatively small holdings and the effect of size of holding may account for the lack of significance of land ownership. Moreover, surprisingly, part-owners were found to be significantly less likely to exit farm occupation compared to the full land owners (odds ratio = 0.382; $p<.10$, model 2). This could be partly because part-owner farmers were committed to farming and rented-in additional land for cultivation. The effect of which turned out to be statistically non-significant after the addition of proportion of non-farm households in the community.

Each additional year of education of the household head increased the odds of farm exit by 7 percent (odds ratio = 1.072; $p<.05$, model 2). However, the effect of this variable was suppressed particularly when the strata variable, the location of a household from the urban center, was included in the model. This could be because relatively more educated persons live in the vicinity of the urban center than in areas away from it.

Since the households belonging to the Terai Tibetoburmese groups are traditionally agriculturally based and are indigenous to this setting, they were expected to be less likely to shift farming occupation compared to other ethnic groups. However, the results indicated that the households belonging to the Terai Tibeotoburmese ethnic groups are not significantly different from other ethnic groups in changing their occupation.

Households that use modern farm inputs were assumed to enjoy the benefit from their use and therefore, were not expected to leave farming as frequently as those who do not use technologies. As per expectations, the use of bio-chemical inputs such as fertilizers and pesticides and mechanical inputs such as tractors, pumpsets, and farm implements negatively influenced occupational shifts by households net of other socioeconomic factors. But this effect was statistically significant only for using bio-chemical input (model 2). However, the statistical significance was lost when neighborhood factors particularly the location of households from urban center was included in the analysis. This result suggests that modern input use has no independent effect on farm exits.

6.4.2.3. Neighborhood Characteristics and Occupational Mobility

The effects of neighborhood contextual factors on occupational transition are provided in model 3 (Table 6.2). I examined the effects of the proportion of non-farm households in the community, the number of services such as banks, bus services, cooperatives, schools, health services and employment opportunities available within a 10-minute walk from the neighborhood, whether a neighborhood experienced any shock of flooding during 1996 and 2001, the presence of the Small Farmer Development Program and the household's proximity to the urban center of Narayanghat. Over 8 percent (Pseudo R-square = 8.45 percent) of the variation in the dependent variable occupation change was explained by these community characteristics.

Among the community characteristics, the proportion of non-farm households in the community statistically significantly and positively contributed to farm exit (odds ratios = 1.041; $p<.001$; model 3). The effect of the number of services available within a 10-minute walk, which was statistically significant and positive without controlling for the effect of proportion of non-farm households in the community, turned out to be statistically non-significant when the later variable was simultaneously added in the model. This could be because households living in communities with relatively more proportion of non-farm households demand certain services, which help create off-farm employment opportunities, thus encouraging other farm households to leave farming. The presence of the Small Farmer Development Program was negative but not statistically significant. In addition, there was no clear rural-urban difference in farm exit.

6.5. Summary

I explored the effects of various household-level demographic, socioeconomic and neighborhood contextual characteristics on the occupation shift of a household from farming to non-farming activities in the western Chitwan Valley. Among the household demographic characteristics are the presence of working-age adults, the number of working-age children, the number of children below 6 years of age, presence of elderly members and age of the household head. The socioeconomic characteristics included are total cultivated size of land, land ownership, technology use in agriculture, livestock ownership, education of the household head, and ethnicity. The proportion of non-farm households in the community, the presence of services such as banks, bus services, cooperatives, schools, cooperatives, and off-farm employment opportunities within a 10-minute walk from the neighborhood, the presence of the Small Farmer Development Program, and the proximity of households from the major market center of Narayanghat are the community context variables examined.

The findings revealed that the presence of working-age individuals, particularly children, has a negative but independent effect on farm exit. The result suggests that the availability of working-age members in farming households encourages a household to continue farming. However, the insignificant effect of the number of working-age males and females on occupation transition overshadows this conclusion. It necessitates the need for a detailed study to explain why the presence of working-age children discourages occupation transition in this setting of western Chitwan Valley. Information on children's time allocation in farming, schooling, and other activities, and household income sources, and their distribution in various activities including child development (for example, schooling) may be necessary to answer the question.

Size of cultivated land and livestock ownership significantly and negatively contributed to occupation change of a farm household. However, other factors such as education of the household head, land ownership and ethnicity were not statistically important in the decision to exit farming. Among the community characteristics, proportion of non-farm households in the community mediated the effect of the availability of services, both of which increased the odds of occupation change from farm to non-farm activities.

In conclusion, households' demographic and socioeconomic characteristics and the presence of community services in the neighborhood are important factors contributing to change of occupation of households from farming to non-farming activities. The findings are important in the sense that the Nepalese government has set a priority to create off-farm employment opportunities in the country and lessen the pressure of population in agriculture. This study identifies some of the important characteristics that encourage or discourage the movement of a household out of farming. However, the answer to questions such as which off-farm sector these households enter and what facilities and services should be created to provide employment to the persons living in these households are not clear. Since the data set used in this study has not collected this information, a further study is needed.

CHAPTER 7

SUMMARY AND CONCLUSIONS

The purposes of this dissertation were twofold. First, it examined the effects of household-level demographic, socioeconomic and neighborhood-level characteristics on the use of labor-saving bio-chemical and mechanical technologies in agriculture. Second, it explored various household demographic, socioeconomic and neighborhood contextual factors that affect the occupational shift of households from farming to non-farming activities. I used household and neighborhood-level data from the western Chitwan Valley located in south central Nepal to examine these issues. Information collected in 1996 and 2001 from farm households living in 151 neighborhoods of the Chitwan Valley Family Study (CVFS) area provided data for this study.

7.1. Factors Affecting Technology Use in Agriculture

Technology use in crop production is one major dependent variable used in this study. To examine the effects of household demographic, socioeconomic and neighborhood characteristics, I used two separate packages of technological inputs used by farmers in crop production in 1996: (i) a bio-chemical technology package that included chemical fertilizers and pesticides/herbicides, and (ii) a mechanical technology package that included the use of farm machines such as tractors for plowing, pumpsets for irrigation, and other improved farm implements such as threshers, corn shellers, and chaff-cutters used to perform other agricultural operations.

7.1.1. Demographic Characteristics and Technology Use

Farming in Nepal is largely subsistence and most farm activities are performed by family members except peak season agricultural operations such as rice transplanting and harvesting (Bhandari et al. 1996-97). In this context, the availability of family members may have an important impact on the adoption of labor-saving modern farm inputs such as chemical fertilizers, pesticides, tractors, pumpsets, and other farm implements. Since both of the technological packages, bio-chemical and mechanical, used in this study are labor-saving in nature, it was hypothesized that the presence of working-age family labor per unit of cultivated land would negatively affect the use of these inputs.

Some of the agricultural operations are gender specific (Acharya and Bennet 1981; Sachs 1996; Agarwal 1992; Bhandari et al. 1996; Boserup 1971, 1990; Prasad and Singh 1992; Rani and Malaviya 1992; Singh et al. 1992). For example, plowing is solely done by males and weeding is primarily done by females. Therefore, I also examined if the presence of working-age males and females has differential effects on the use of these technologies.

The results provide evidence in support of the hypothesis that the presence of working-age family members reduces the likelihood of using both bio-chemical (chemical fertilizers and pesticides), and mechanical (pumpsets and farm implements, and tractors) technologies. While the use of any one or two or more items of bio-chemical inputs was linearly but negatively related to family labor availability, there was a curvilinear effect of labor availability on the use of mechanical inputs. The use of mechanical inputs increased after a certain point, when there was an increase in labor availability per unit of land. This result indicated that if there is more labor available per unit of cultivated land, farmers use more modern inputs possibly to increase food production for more people in the household.

The results of gender disaggregated labor availability also showed a consistent result signifying the importance of women in the technology use decision in Nepalese agriculture. While women are primarily responsible for carrying and applying farmyard manure, and weeding, plowing and irrigating fields are primarily done by men. However, the presence of women and men contributed to non-adoption of both of the bio-chemical as well as mechanical inputs. Interestingly, the effect of the presence of women was stronger than the presence of men suggesting women's important roles in the decision to use modern inputs. This could be due to the fact that more women are primarily engaged in farming (FAO 2000; Kumar and Hotchkiss 1988; NESAC 1998), and they spend more time in household and farming activities including harvesting, threshing of grains, and working behind the plow during land preparation (FAO 2000). This implies that women are also responsible to perform farm activities that are supposed to be done by men as long as working-age women are available in the household. Looking at the scenario, it would be worth to note that "…mechanization in agriculture is found mainly in men's work. Women's work, (including household tasks) has remained predominantly manual" (Singh et al. 1992:279-280).

Moreover, contrary to the assumption that older individuals are reluctant to use modern inputs, it was found that households headed by older members were more likely to use mechanical technology, particularly the pumpset and other farm implements. Similarly, the result also indicated that migration of individuals from a household for economic reasons also contributed to mechanical input use in farming.

In conclusion, the results provide strong evidence that the presence of working-age male and female family members per unit of cultivated land reduces the adoption of modern technologies in crop production. In addition, the presence of women is very important in the decision to use modern farm inputs. In the past, women's roles were neglected in the agricultural development of Nepal (APP 1995). However, this result clearly suggests the importance of women in farming.

7.1.2. Socioeconomic Characteristics and Technology Use

I also examined the effects of household socioeconomic characteristics such as land ownership, land quality, land fragmentation, livestock ownership, and ethnicity on technology use. Overall, land ownership, land quality, education of the household head, ethnicity and land fragmentation contributed to the use of both bio-chemical and mechanical technologies in agriculture.

Land ownership was found to be an important contributor to both the bio-chemical and mechanical input use in agriculture. Full land owners were found to be more likely to use these modern inputs than sharecroppers. It is likely because full land owners have relatively more income, have legal ownership right to the land, and receive benefits from land management and returns to equity, not shared by sharecroppers (Stokes and Schutjer 1984). Therefore, they are motivated to use modern inputs. To the contrary, sharecroppers have to use inputs themselves, but the output has to be shared between land owners and sharecroppers. Thus, they have little incentive to use inputs and improve their land. In addition, sharecroppers are mostly subsistence farmers with relatively small land holdings and do not use these purchased modern inputs.

This finding is relevant in the context where land ownership has always been an important issue in the development of Nepalese agriculture (NPC 2003). In Nepal, dual land ownership prevails where both land owner and cultivator have dual rights on the same piece of land and none of them have sole right for its appropriate use. Therefore, every plan has emphasized abolishing this kind of dual land ownership, and this finding provides further support for that policy.

The use of mechanical technology also differed by quality of land measured in terms of *khet* or *bari* land. Those who cultivated *khet* land were more likely to use two or more items of mechanical inputs than those who cultivated only *bari* land. However, availability of irrigated land has a positive, but not an independent effect on the use of chemical fertilizers and pesticides.

Another important factor contributing to the use of bio-chemical and mechanical technologies is ethnicity. It is believed that High Caste Hindus are privileged and other ethnic groups are disadvantaged in Nepal (Acharya and Bennet 1981; NESAC 1998). High Caste Hindus have the most access to economic and non-economic opportunities compared to other ethnic groups. The findings of this study also show that households belonging to the local indigenous Terai Tibetoburmese groups (for example, Tharu, Kumal, and Darai) and Low Caste Hindu (for example, Kami, Damai and Sharki) are relatively disadvantaged in terms of using both bio-chemical and mechanical inputs as compared to those belonging to the High Caste Hindu (for example, Brahmin and Chhetri). This finding provides support for a focus on the local indigenous population and Low Caste Hindu households to encourage them to use modern inputs in farming and improve their livelihood.

The number of parcels cultivated by a farm household, also called land fragmentation, was found to increase the use of both bio-chemical and mechanical technologies in crop production. The result is surprising because increased numbers of parcels were expected to reduce care and management of crop fields and therefore, would reduce the use of improved inputs. This surprising result, however, could be due to the difficulty in transporting and applying farmyard manure in the distant fields as reported in Ethiopia (Igbozurike 1970, cited in Gebeyehu 1995). Although this finding does not seem important from a policy perspective, it is important to understand why increased land fragmentation increases the use of modern inputs in the Chitwan Valley.

Education of the household head contributed positively to the use of these inputs. Ownership of a radio and/or a television also increased the use of mechanical inputs. Both of these results indicate the importance of information, education, and communication in technology use decisions and therefore, provide support for continuing active agricultural extension programs in Nepal.

7.1.3. Neighborhood Characteristics and Technology Use

The effects of neighborhood contexts such as the availability of services (banks, cooperatives, and bus services within a ten-minute walk), the presence of the Small Farmers Development Program in the community, and rural-urban location of farm households were examined. Since all these services increase the accessibility to modern inputs, I hypothesized that proximity to community services, the presence of the Small Farmers Development Program, and proximity of a household to the urban area would enhance the uses of both bio-chemical and mechanical technologies in farming.

The effect of the access to community services which is the priority of the Nepalese government's agriculture development program was, however, not clear. For instance, the increased access to services in the community increased the use of mechanical inputs but decreased the likelihood of using chemical fertilizers and pesticides, which is contrary to expectations. The effect of rural-urban location of farm households, however, has a mixed effect on the use of various farm inputs. Interestingly, households living in remote areas were more likely to use both of these farm inputs compared to those who are living in the vicinity of urban areas. These results provide evidence that inadequate and untimely distribution of inputs is not necessarily a major reason behind low or no use of farm inputs in Nepalese agriculture.

Overall, I conclude that the presence of working-age family members is a key to non-adoption of labor-saving bio-chemical and mechanical technologies in farming. Although the presence of both men and women family labor is important in technology adoption decisions, the presence of women seemed to be much important. Household socioeconomic factors such as land ownership, land quality, education of the head of household, exposure to communication media, and ethnicity are important in the adoption of farm technologies. However, their effects vary by type of technology used. Finally, access to community services does not appear to be important in the adoption of modern farm inputs at least in this Chitwan Valley setting.

7.1.4. Policy Implications

This study of the factors affecting technology use in agriculture has several policy implications. Previous studies have primarily focused on economic factors contributing to technology adoption. While some of this research has examined factors such as prices, land size, and income contributing to technology use (for example, Feder et al. 1985; Feder and O'Mara 1981; Rauniyar and Goode 1996), other research has focused on labor replacement effects of technologies in agriculture (for example, Agarwal 1983; Bartsch 1977). The major contribution of this study is from a demographic perspective that examined the effects of the presence of working-age family members, their gender composition, the age of the household head, and migration of individuals from a household on the use of modern inputs in agriculture. This study has also contributed to the existing literature by examining the effects of other household socioeconomic and neighborhood contextual factors on farm technology use. In Nepal, to my knowledge, there is only one study conducted in 2002 by the Fertilizer Unit of the Ministry of Agriculture and Cooperatives (2003), which has primarily focused on the effects of household-level factors such as income, land size, ethnicity, and distance to market on the use of chemical fertilizers. This study has not covered other inputs.

The findings of this study are also important because the Ministry of Agriculture and Cooperatives, thus far, has emphasized the distribution of inputs and their prices with the assumption that assured supply of inputs would encourage farmers to use them. This is reflected in national policy documents – the Agricultural Perspective Plan (1995), the Ninth Plan 1997-2002 (NPC 1998), and the current Tenth Plan 2002-2007 (2003b). For instance, the major policy strategy focuses on "inadequate supply of chemical fertilizers, improved seed, improved breed, and agriculture loan" as the important problems of agriculture (NPC 1998:321). Further, the growth strategy for agriculture focused by the Tenth Plan document is "…to modernize, diversify and commercialize crop and livestock production by expanding the use of technology, and increasing the access of farmers to modern agricultural inputs and credit" (NPC 2003a:45).

The existing agricultural development policies in Nepal basically focus on ensuring distribution of agricultural inputs in the country while neglecting other factors that affect the decision to adopt technologies at the household-level. Obviously, the availability of inputs may be a constraint in the Hills and the high Hills and other remote districts of the country where the distribution of inputs is obstructed by rugged geographic terrain and transportation difficulties. However, such problems are not prominent in the Terai particularly in the Chitwan Valley. Therefore, in a country where the family is the major source of labor and almost all activities including plowing, irrigating, weeding, and roughing of infested plants are performed by using household labor, the provision of modern inputs may not be the primary solution to increasing their use. It is also important to understand the importance of other household-level demographic and socioeconomic factors affecting modern input use. However, these issues are ignored by these documents including the Agricultural Perspective Plan, which is one of the major contributions of this study.

Gender is an important aspect of the Nepalese farming system. A large majority of women are engaged in farming and spend significant time in household as well as food production activities. Moreover, some farming activities are primarily done either by men or women. For example, land preparation is specifically performed by men and weeding is primarily done by women (for example, Boserup 1981; Sachs 1996; Bhandari et al. 1996). In this context, the roles of women may be equally important in farming decisions. One of the major strengths of the Agricultural Perspective Plan, the Ninth Plan and the current Tenth Plan is that these documents realize the importance of the role of men and women in various aspects of farming. For example, the APP, which is the basis of the Ninth and Tenth plans specifies the importance of women in various aspects of agriculture such as production, marketing, agribusiness, and technology use and suggests bringing women into the mainstream of agricultural development. But it is not clear in which aspects women's roles are important and how they will be brought into the mainstream of development. Still male farmers are contacted while designing and implementing various agricultural development programs. The findings of this study provide evidence that the presence of working-age females is also important in the decision to use agricultural inputs, and therefore, their roles should not be ignored. This is an important contribution to the sociology of agriculture literature in developing countries.

The findings of this study may have indirect but important demographic implications, for example, on human fertility. Obviously, households that use human labor instead of labor-saving modern inputs have a high value of labor. Therefore, individuals in such households may prefer to have larger family sizes in order to maintain a large pool of labor in the future. Moreover, children are widely used in carrying out farming and other household activities in Nepal (Bhandari et al. 1996; Filmer and Pritchett 1997; Kumar and Hotchkiss 1988; Loughran and Pritchette 1997). The demand for child labor is one of the explanations for high fertility among individuals of agrarian societies (Filmer and Pritchett 1997; Loughran and Pritchette 1997; Stokes and Schutjer 1984). Conversely, Rosenzweig (1977) in his framework of the demand for children in agricultural households shows that the use of labor-saving modern inputs in agriculture reduces the productive value of child labor, which ultimately reduces birth rates. Drawing from Rosenzweig (1977), it can be argued that individuals living in farm households that use labor-saving modern technological inputs may prefer to have smaller family sizes as a result of decrease in the productive value of child labor. As a consequence, these individuals may have positive attitudes toward using contraceptives. In one of the studies conducted in this Chitwan Valley setting, Bhandari and Shrestha (2005) found that individuals, particularly women from a household that used technological inputs in crop production were more likely to use modern contraceptives to delay or avoid pregnancy than those from households that did not use any modern inputs. If this result holds true in determining actual contraceptive and fertility behaviors of individuals, which is not the focus of the present study, on the one hand, food production per unit of land can be increased by encouraging farm households to use modern technological inputs, on the other hand, pressure of population in agriculture can be gradually lessened in the long-term by encouraging farmers to have smaller family sizes.

The findings of this study further suggest that household socioeconomic factors such as land ownership, land quality, education of the household head, exposure to communication media, and ethnicity are also important in technology use decisions. The findings indicate that land owners are more likely to use modern inputs in crop production as compared to the sharecroppers. This finding is important from a policy perspective. For instance, the Nepalese government has realized the existing dual land ownership system (also called *Mohiyani*) as an important problem in agriculture. Therefore, the government has emphasized elimination of the existing dual land ownership system from the very beginning of the land reform history of the country. The

APP (1995) also emphasizes this issue that "[w]hen land tenure is surrounded by uncertainty, investment faces a great many risks…" (p. 271). The document cites the Agriculture Census of 1991 that about 15 percent of the holdings are rented-in land in Nepal, which is more serious in the Terai (19 percent). The government had its goal to eliminate the dual land ownership system during the Ninth plan and expects to achieve this goal during the Tenth Plan (NPC 1998; NPC 2003a). However, there has been no significant progress toward this goal. In this context, the findings of this study provide empirical evidence that farmers should have full ownership rights in order to benefit from agriculture and therefore, such a dual land ownership system should be eliminated as soon as possible.

There is no need to emphasize the roles of education and communication on technology use. The findings of this study also support this argument. Therefore, strengthening of agricultural education through formal as well as informal education campaigns such as adult education focusing on gender might have important implications in the agricultural development of the country. Further, ethnicity has never received a priority in agricultural development programs. The findings of this study, however, indicate that use of technology also varies by ethnicity. The traditional farming communities belonging to the Terai Tibetoburmese groups (for example, Tharu, Darai, and Kumal) and Low Caste Hindu (for example, Kami, Damai, Sarki) are disadvantaged in terms of technology use in farming compared to the households of High Caste Hindu. The findings of this study also suggest that efforts be made to encourage these ethnic groups to join the mainstream of agricultural development. Although fragmentation of holdings in the Terai was expected to hinder investment (APP 1995), the findings of this study suggest land fragmentation is not an obstacle to technology use.

Finally, the availability of services such as banks, cooperatives, and bus services do not show any significant impact on bio-chemical technology use at least in the Chitwan Valley setting. This finding questions the relevance of the government's policy to increase adequate and timely provision of modern inputs to encourage their use by farmers. Similarly, there is no consistent rural-urban difference in technology adoption. The failure to find significant effects of service availability or rural-urban difference may be because these services are accessible in the Valley unlike other parts of the country.

7.1.5. Implications for Further Research

One of the important limitations of this study is that the findings are based on information from only one part of a district in the Terai plain. The findings may not be generalized for all other districts, thus suggesting the need for conducting similar studies in other parts of the country. Moreover, the findings related to mechanical technology use may not be appropriate for policy purposes for the Hill and Mountain districts of Nepal, where machines such as pumpsets, threshers and tractors cannot be used due to the topography. A similar but different study focusing on the needs of the Hill and Mountain districts would be more appropriate.

Interestingly, the effect of the female labor pool in a household on the use of mechanical inputs was found more important than the effect of their male counterparts, which was not expected. This necessitates a further study exploring possible reasons focusing on gender roles in allocating household economic resources including labor in the household. From a demographic perspective, a further research is also needed to examine the demographic impacts of modern input use in agriculture, for example, human fertility. Moreover, the effects of service availability and rural-urban difference on technology use needs to be validated by conducting research in other parts of the country.

The effect of land fragmentation was not in the expected direction. This finding also suggests the need for a study as to how and in what conditions land fragmentation is or is not a problem in Nepalese agriculture. Moreover, since the effects of community contexts on the use of modern inputs are not clear, studies should be conducted in other parts of the country.

Finally, it is a well-known fact that controversies exist about the economic benefits and the environmental impacts arising due to the use of modern farm inputs worldwide. It is also suggested that research examines the socioeconomic and environmental impacts of current agricultural policies in Nepal that focus on increased use of green revolution technologies.

7.2. Occupational Mobility (Farm Exit) of Farm Households

Change of occupation by farm households to non-farm activities in Nepal is a recent phenomenon. The second purpose of this study is to explore the effects of various household demographic, socioeconomic and neighborhood characteristics on the occupational change of a household from farming to non-farming activities.

In the western Chitwan Valley of Nepal, the 2001 household survey reported that some of the households that were farming during the 1996 survey changed their occupation to non-farm activities by 2001. I defined such a shift in occupation between

1996 and 2001 as occupational mobility for purposes of this study. I used descriptive statistical tools to describe the data and logistic regression to examine the net effects of various factors on farm exit.

7.2.1. Demographic Characteristics and Occupational Mobility

The availability of working-age women and men, the number of children below 6 years of age, the number of working-age children (6 to 14 years of age), the presence of elderly members in a household, and the age of the household head were considered household demographic characteristics potentially influencing household occupational change. It was hypothesized that presence of working-age individuals would reduce the likelihood of occupational shift out of farming to non-farming activities.

The findings suggest that the availability of working-age family labor pool, particularly the presence of working-age children is an important hindrance to occupational shifts of farm households. It could be mainly because children are widely used in carrying out farming and other household activities in Nepal (Bhandari et al. 1996; Filmer and Pritchett 1997; Kumar and Hotchkiss 1988; Loughran and Pritchett 1997) and share a major portion of the household work burden (NPC and UNICEF/Nepal 1996).

7.2.2. Socioeconomic Characteristics and Occupational Mobility

The socioeconomic characteristics included in the study of household occupation change were size of cultivated land, land ownership, technology use in agriculture, livestock ownership, education of the household head, and ethnicity. Although the size of cultivated land, livestock ownership, education of the household head, and bio-chemical technology use appeared to be significant contributors to household occupational shifts, the size of cultivated land, livestock ownership and technology adoption have independent and inhibiting effects on occupation change of a farm household when other factors are controlled. Education of the head of the household slightly increased the odds of occupation change out of farming, but this finding was not statistically important when all other factors were controlled. Occupational shifts from farming to non-farming activities also did not vary by ethnicity.

7.2.3. Neighborhood Characteristics and Occupational Mobility

The proportion of non-farm households in the community, availability of services such as banks, bus services, cooperatives, schools, employment opportunities, the presence of the Small Farmer Development Program in the community, and rural-urban location of households were used to examine the effects of community characteristics on occupation change.

The findings suggest that the increased proportion of non-farm households in the community positively and significantly contributed to farm exit. Interestingly, the effect of access to various community services on farm exit, which was positive, was mediated by the presence of non-farm households in the community. This could be because communities with a greater proportion of non-farm households may have demanded various non-farm services, the development of which could have encouraged farm exit due to an increase in non-farm employment opportunities. While this is a plausible interpretation of this finding, confirmation of this explanation requires data on the employment and occupations of those who left farming.

7.2.4. Policy Implications

This study contributes to our understanding of why some households leave farming and why others continue by examining some of the factors that encourage or discourage occupational shifts of farm households. For example, while the availability of community services, the proportion of non-farm households in the community, and the education of individuals in the household could lead to occupational changes, the presence of working-age individuals particularly children, the availability of cultivated land and livestock ownership discourage farm exit.

It is well recognized that the pressure of population on agriculture, which is increasing over time, is one of the major problems facing Nepal (Ashby and Pachico 1987). For example, a population density of only 102 persons per square kilometer of land recorded in 1981 increased to 158 persons per square kilometer in 2001 (CBS 2002). Moreover, the gross cropped area per agricultural worker has decreased from 0.47 hectares in 1971 to 0.43 hectares by 1991 (Silwal 1995). Considering this as a serious problem of development, the Nepalese government, particularly in the Ninth and Tenth Plans, emphasized the creation and provision of off-farm employment opportunities (NPC 1998, 2003b) with the goal of diverting individuals away from agriculture.

Since the goal is to lessen the pressure of population in agriculture, the findings of this study have important policy implications. For example, if parents are encouraged to use household resources for the human capital development of children such as schooling, rather than using their labor in farm and household activities, the effect of the availability of working-age children on occupational shifts could be different. Because educated individuals are more likely to move away from farming in the future as suggested by the effect of education of the household head.

The findings also suggest that the access to cultivated size of holding and livestock ownership are important factors discouraging farm exit. These findings have important policy relevance. In Nepal, over 80 percent of the economically active people are engaged in farming. Many farm households own and cultivate very small land holdings. For example, over one-half of the farm households had less than one hectare of farm land in 2001. These small farms are considered uneconomical for production. Moreover, agriculture and livestock keeping are highly integrated in the subsistence agriculture of Nepal. If we attempt to create non-farm employment opportunities suitable for small land holders or those with no animals and encourage them to move out of farming, the pressure of population in agriculture can be relieved in the future.

7.2.5. Implications for Further Research

Although this study investigated the effects of household-level demographic, socioeconomic and neighborhood characteristics on occupation change of farm households toward non-farm activities, this research does not provide information on the sector these farm households enter. This question needs to be investigated in detail in order to create necessary services and facilities in that direction. Moreover, whether these households do better or worse in off-farm sectors or whether these households return to farming sector jobs is also not clear. Secondly, among the demographic factors, the availability of working-age children was found to be an important inhibiting factor for occupation shift of a farm household. However, why their availability in a household is a hindrance to occupation change in this setting remains unanswered. Information on children's time allocation in farming, schooling, and other activities, and household income sources, and its distribution in various activities including child development (for example, health and schooling) may be necessary to answer the question.

In summary, the first part of this study provides possible explanations behind no or low use of modern inputs in agriculture in Nepal. The findings provide evidence that the presence of family labor is one of the important contributing factors behind non-adoption of modern inputs along with other socioeconomic and neighborhood characteristics. Moreover, the role of women in the decision to use modern inputs is quite important. This could be an important explanation behind no or low adoption of modern inputs in the country. This situation has caused low and stagnant agricultural productivity, one of the two major problems facing Nepal (Ashby and Pachico 1987).

The second part of this study explores some of the important factors affecting occupational change of farm households. Our findings suggest that the presence of working-age children was found to discourage a farm household's movement out of farming. Interestingly, while the availability of family labor hinders the use of modern inputs, it also discourages farm exit. Thus, encouraging farm households to invest in the human capital development of children would increase the use of farm inputs as well as farm exit in the long-term. Second, our findings provided evidence that access to cultivated land and ownership of livestock are two important inhibiting factors to move out of farming. Our policy should focus on encouraging small holder farmers with no animals to move out of farming to non-farm activities. This is possible through the development of various non-farm employment opportunities in the community. These findings suggest an understanding of the possible ways to relieve population pressure in agriculture, which is the second important problem facing the country (Ashby and Pachico 1987).

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EDUCATION

Year	Degree	Institution and Country	Field of Study
2000-2006	Ph. D.	Penn State University, USA	Rural Sociology and Demography
1992-1993	M. Sc.	Asian Institute of Technology, Thailand	Rural Development Planning
1983-1986	B. Sc.	Tribhuvan University, Nepal	Agricultural Sciences

TEACHING AND RESEARCH EXPERIENCES

1987-2000	Lecturer, Institute of Agriculture and Animal Science, Tribhuvan University, Nepal
2000-2006	Graduate Research Assistant, Penn State University, USA
1995-2000	Faculty Research Associate, The Population and Ecology Research Laboratory, Tribhuvan University, Nepal and University of Michigan, Ann Arbor, Michigan

RECENT PUBLICATIONS

Prem Bhandari, R. C. Stedman, A. E. Luloff, J. C. Finley and D. Diefenbach (In Press). "Effort versus Motivations: Factors Affecting Antlered and Antlerless Deer Harvest Success in Pennsylvania." *Human Dimensions of Wildlife,* 11(6)

Prem Bhandari. 2004. "Relative Deprivation and Migration in an Agricultural Setting of Nepal." *Population and Environment* 25(5): 475-499

Shivakoti, G., W.G. Axinn, P. Bhandari and N. B. Chhetri. 1999. "The Impact of Community Context on Land Use in an Agricultural Setting." *Population and Environment* 20(3): 191-213

RECENT PRESENTATIONS

Prem Bhandari, A. E. Luloff, J. C. Finley, R. C. Stedman and D. Diefenbach. 2006. "Deer Harvest Success in Pennsylvania's Private vs. Private Land." Presented at the International Symposium on Society and Resource Management Annual Meetings, Vancouver, June 3-8.

Ryan, Andrea K., Melissa E. Hobbs and Prem Bhandari. 2006. "The Youth Agricultural Employment Project Early Findings." Presented at the Rural Sociological Society Annual Meetings, Louisville, Kentuky, August 10-13.

Prem Bhandari and Sundar S. Shrestha. 2005. "Labor Availability, Agricultural Technology Use and Contraceptive Attitudes in Nepal." Presented at the Population Association of America (PAA) Annual Meetings, Philadelphia, March 31-April 2.

Prem Bhandari, A. E. Luloff, J. C. Finley and R. C. Stedman. 2005. "Factors Affecting Antlered and Antlerless Deer Harvest Success in Pennsylvania." Presented at the Rural Sociological Society Annual Meetings, Tampa, August 8-12.

Sundar S. Shrestha and Prem Bhandari. 2005. "Environmental Security and Labor Migration in Nepal." Presented at the XXVth International Population Conference of the IUSSP, France, July 18-23.

Prem Bhandari, S. S. Shrestha and N. Chhetri. 2004. "Child Labor and Forest Resource Collection: Variation in Individual Fertility Preferences in Nepal." Presented at the Population Association of America (PAA) Annual Meetings Boston, Massachusetts, April 1-3

FELLOWSHIPS/SCHOLARSHIPS

2003-2004 The Population Reference Bureau 2003-2004 Fellows Program Fellowship in Population Policy Communication, Washington, D.C.

2001-2002 The Hewlett Foundation Fellowship to continue Ph.D. studies at Penn State, University Park.

2000-2001 The Ford Foundation Grant to continue Ph.D. studies at Penn State, University Park.

1999 The Fogarty Grant to attend the Inter-University Consortium for Political and Social Research (ICPSR) Summer Program at University of Michigan, Ann Arbor.

MEMBERSHIP IN ORGANIZATIONS

2001-present	Population Association of America (PAA)
2001-present	Rural Sociological Society (RSS)
2004-present	International Union for the Scientific Study of Population (IUSSP)
2006-present	Canadian Population Society (CPS)