Ecological Variation and Crop Cultivation in Nepal

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Abstract: This paper has analyzed cultivation of crops in three Nepalese ecological zones: hill and mountain ridges, hill and mountain valleys, and Terai plains, with data collected from the Western Development Region. Within the given state of farmlands and input use crop production were analyzed and discussed in the context of these ecological zones. Data for this empirical study were collected using a cross-section approach, which deemed the elimination of biasness in selecting research areas, and best representation of variation, both ecological and cultivation of crops and livestock rearing. Two levels of sampling—area and households—were done to identify the representative locations and households, respectively. The states of the farmlands (size of landholding and its distribution, fragmentation of landholding, nature and quality of farmlands), and input use (improved varieties, farm chemicals, modern tools and farm machinery) were discussed with reference to their ecological variations and were found them as the function of the ecological entities. Based on these discussions, a crop production (cropping pattern, crop intensity, crop diversification, crop specialization, crop productivity) as well as livestock rearing were analyzed taking ecological zones as the sole independent variable. The paper describes cultivation of crops and livestock rearing in the three ecological zones as well as it has presented the patterns and trends emerged as results of the ecological variations. These crop production tendencies showed the lasting practices of the traditional crop production and livestock rearing system with household strategies for subsistence, which was still a function of ecological entities.

KEY WORDS

Ecological variation, crop production, input use, cropping pattern, cropping intensity, crop diversification, traditional practice, modernization of agriculture, livestock rearing.

1. Introduction

Before the diffusion of agricultural innovations, farmers in remote rural areas produced the same crops still following the techniques used by their forefathers. Any change that occurred was a spontaneous response of the population pressure to agricultural land (Boserup, 1965). Landholding, input use and use of modern technology remained the major bottlenecks in increasing agricultural production. The use of crop specialization or diversification practices those increased production and net cash income depends on the nature of a household economy (Imink and Alarcom, 1993).

Intensive and multiple cropping, water management, diversification of agricultural activities, use of modern appropriate technology, and agrarian reforms are the major components that have the potential for improving agricultural production (Dupriez and De Leener, 1988; Wen et al., 1992), and, hence increasing income (World Bank, 1978, 1990; Lee, 1980; Vaidyanathan, 1980; Tyagi, 1980; Ireson, 1987).

A rational utilization of land resources is another matter of concern for production. It requires two questions to be answered through research. First, what is the technical feasibility of the best agricultural practice for a plot of land based on farm household requirements, manpower and technology available, and second, what is the final net output from such practices ? The level of

technology one should use is determined by awareness, availability, affordability, demonstration or profitability (Tiwari, 1998). If farmers are well informed about the process and consequences of adopting new technology, they accept techniques as they are or modify them to match their need. Similarly, socioeconomic status, holding of material goods and availability of information correlate with the adoption of an innovation (Rogers and Svenning, 1969; Rogers and Shoemaker, 1971), farmers prefer low-cost technology at minimum risk (Rohrer, 1986), more labour with increased income, material attainment and wealth (Mellor, 1967, 1969).

Peasants' subsistence farming practices are devoid of innovations because of lack of knowledge, limited availability of goods, discouragement of the accumulation of wealth by social value systems and religious sanctions (Clawson, 1978). Innovations are also hampered due to farmers' lack of motivation, fatalistic attitudes and dependence upon luck over effort (Rogers and Svenning, 1969). Similarly, the lack of willingness among peasant farmers to save and spend on production inputs rather than on rituals, social customs and unproductive items like ornaments virtually leave nothing to invest on production innovations and adoption of new technology (Shaw, 1987).

The agricultural production system in remote areas of Nepal is predominantly subsistence oriented (Tiwari, 1996; 1998) and Nepal still characterizes the subsistence farming as discussed above. In particular, socioeconomic status of the farmers, low level of education, poor awareness on modern agricultural practices, lack of irrigation facilities, poor extension services and contact with extension agents and insufficient credit disbursement contributed to low adoption of new technology (Pudasaini 1980; Koirala 1981; Rawal 1981; Khadka 1983). Furthermore, despite numerous research works undertaken by a few agricultural development centers located elsewhere in Nepal, little has been discussed on the crop production system with reference to ecological variations in Nepal, despite great variations on geographical and agricultural support services across ecological zones. Given the deficiency of reliable models to explain the relationship between the ecological variations and crop cultivation, an empirical study was warranted as the appropriate one. The core issues of such an empirical research study included an explanation of agricultural output under existing land resources, and the state-of-the-art in production. This study was therefore done to identify the actors and factors of crop cultivation across ecological variations and to analyze their relationship to explain crop production system in Nepal.

2. Research method

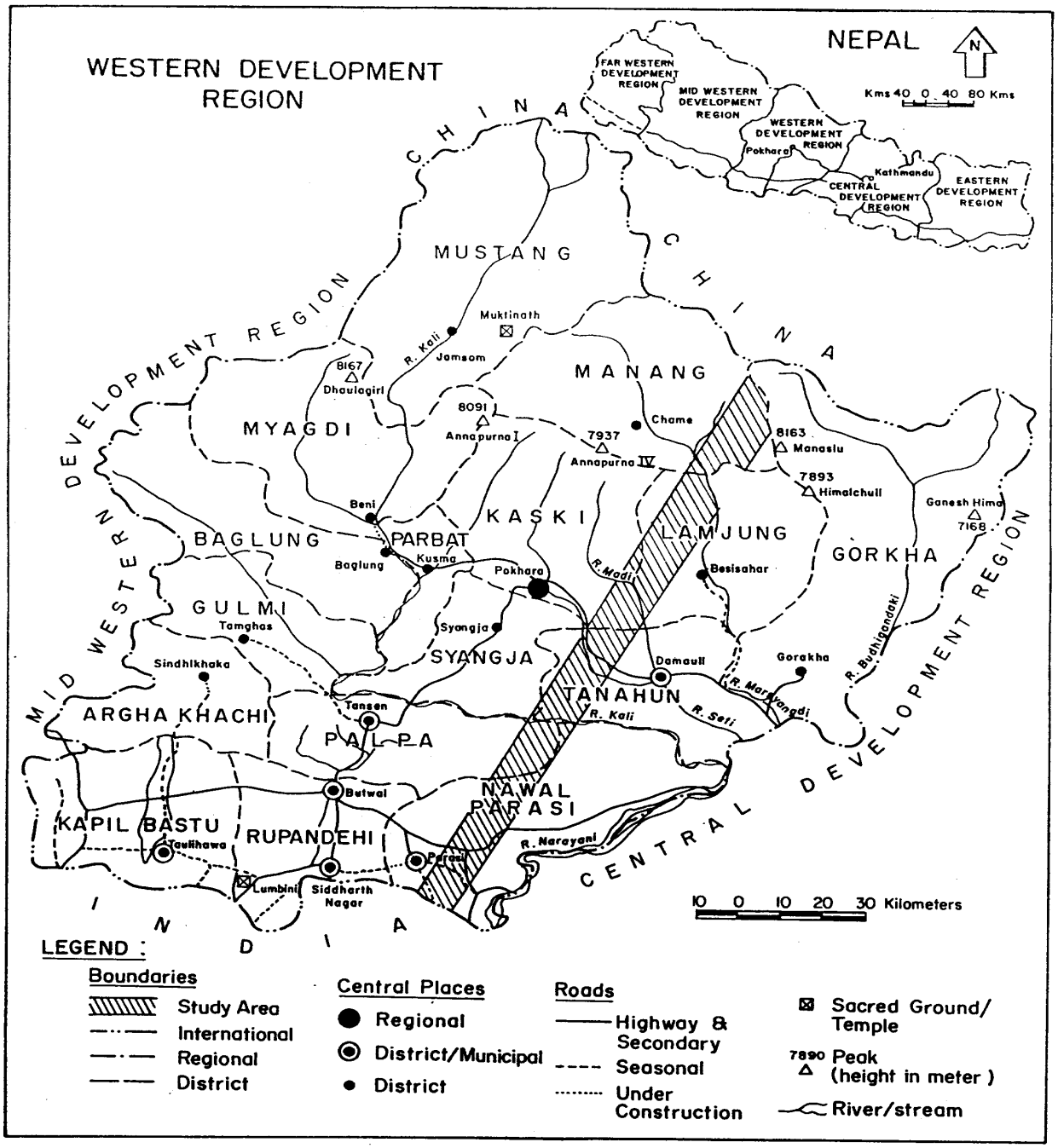
2.1 Study area

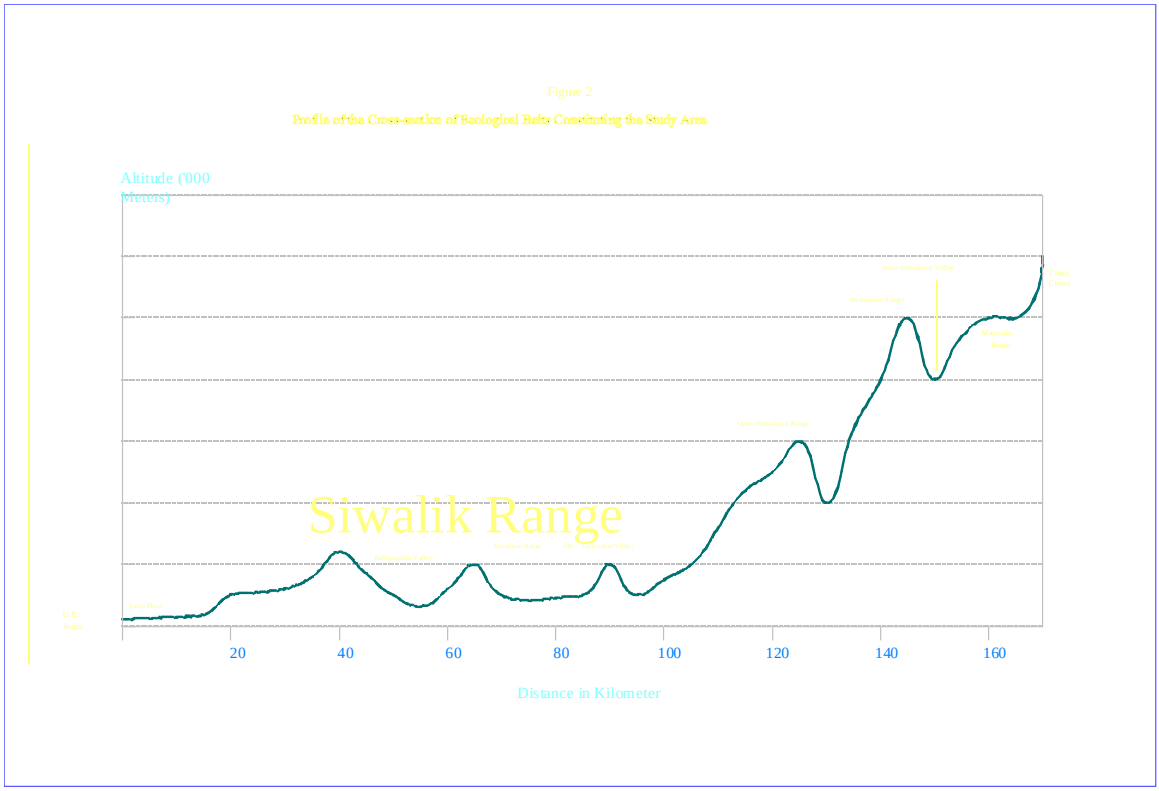
The Western Development Region of Nepal was selected as the study area for the empirical evidence. To ensures an entire spectrum of geo-spatial, agro-ecological and socioeconomic variations were adequately represented as well as to minimize research area selection biases, unlike the conventional approach of selecting a study area identical with the boundaries of river valley, mountain ridge or watershed, urban periphery, fringe or immediate hinterland, corridors along a major route, or project area, this research adopted a cross-section approach which cut across these natural and man-made formations. This cross-section cut through 25 Village Development Committee areas, which are the administrative units at the lowest level of the political and development hierarchical structures, in six districts, extending from the mountain zone in the north through the hills to the Terai in the south. The study area varies in width between five and ten kilometers in east-west and extends over 120 kilometers in north-south direction (Figure 1).

Given the geographical variations and the pattern of agro-ecological relationships, the study area is divided into three zones: the hill and mountain ridges, the hill and mountain valleys, and the Terai plains. The hill and mountain ridges and hill and mountain valleys, however, do not constitute exclusive terrains, are rather intermittent terrains of ridges and valleys in an order of decreasing elevation from north to south and including the Terai plains as the southern most terrain constitute the three main agro-ecological zones of Nepal. All the terrains with common features constitute one specific zone, basically with identical geographical and socioeconomic entities (figure 2).

Figure 1

Location of the Study Area





2.2 Sampling and surveying

This study analyzes data collected in February – April 1994 with the use of survey questionnaire, complemented by structured interviews and field survey conducted using a structured format, for a doctoral dissertation of the author. To identify the locations and respondents to interview for the questionnaire survey, a stepwise design was prepared for the sampling of the settlements and household units.

At the first stage, the settlements were sampled out of the total 225 wards of 25 village development committees fallen along the chosen traverse from six districts. At confidence level of 90% with an expected rate of occurrence at 99.5% and a reliability of ∀5% were determined to calculate the required sample wards. A total sample of 43 wards was derived from 41 settlements units using Cochran's (1977) sample size computation formula. They were identified using a simple random sampling method. As a result, their ecological distribution ranged between 16.7 percent for the Terai plains and 24.1 percent for the hill and mountain valleys (Table 1).

At the second stage, households were sampled from the register prepared for a local election or primary health register of each sampled ward. The total number of households in the sampled wards was estimated at 3,539 units. Since this study covered a rurality as a whole, the rate of occurrence of the parameter in the population was assumed to be more than 95%. Taking into consideration the large area coverage and the likely need for post-data-collection classification of households into various spatial and socioeconomic groups as the basis of analysis, a higher degree of reliability of ∀2% was decided on and the confidence level was fixed at 95%. Under these criteria, a sample size of 404 household units was obtained using Cochran's computation sample size formula, the one used for the area sample design. The 404 households to be surveyed were identified once again using simple random sample method. Overall, the sampled households equaled 11.4% of all households in the sampled wards. At the household level, the distribution of subsamples ranged between 8.4% for the hills and mountain valleys and 14.6% for the hill and mountain ridges (table 1).

Table 1
Wards and households sampled from their corresponding population by physical setting and ecological zone

Physical setting	Ecological zone	Settlements (=Wards)			Households		
		Total wards	Sampled wards	Proportion of samples in total wards	Total households	Sampled households	Proportion of samples in total households
Hills and Mountains	Hill & Mountain Ridges	117	21	17.9	1,387	203	14.6
	Hill & Mountain Valleys	54	11	24.1	1,248	105	8.4
Terai	Plains	54	9	16.7	904	96	10.6

Note: The separation of wards for the hill and mountain ridges and valleys not exclusive in some cases since a ward may be constituted of ridge and valley settlements. However, the sampled households fall under the reported zone.

A survey using standardized questionnaires among household heads from the sampled households was conducted, seeking information under a wider context of research on employment opportunities and earning a livelihood of households in rural regions. The questions asked were related to household composition, command of resources and their utilization, sources of employment, production, earnings and incomes, household expenditure, specific activities operated by a household or activities in which household members were actively involved, as well as the prospects and plans for upgrading and/or expanding existing activities. Information on the state of affairs and reactions to related issues was also explored. Form the set of the wider questionnaire survey, all elements related to crop cultivation and livestock rearing were taken for the analysis of this study.

2.3 Data analysis

To explain and interpret the crop cultivation system, the study has taken three major parameters for analysis: farmlands (size of landholding and its distribution, fragmentation of landholding, nature and quality of farmlands), input use (improved varieties, farm chemicals, modern tools and farm machinery) and crop production (cropping pattern, crop intensity, crop diversification/specialization, crop productivity). This research has taken ecological zone as an independent variable to reflect the ecological variations in the entire discussion of the research findings. Thus, each parameter was described, explained and interpreted in reference to the three ecological entities, using descriptive and diagnostic statistics. Similarly livestock, rearing which goes side by side in a subsistence rural setting, has also been analyzed in reference to some ecological entities. Even the relationship of the independent variables, like that of land resources and input use with production systems are discussed in relation to ecological entities. Other specific analytical tools which are used for the analysis of a few particular parameters are discussed where relevant.

2.4 Description of the of the three ecological zones

Physiographically, the study area is diverse. Its elevation ranges from 100 meters at the Terai near Indian border in the south, about 7,000 meters in the main Himalayan range, to about 4,000 meters in the north at the Chinese border (figure 1 and 2).

The Terai zone is the lowest terrace in the traverse and it consists of alluvial plains. The Siwalik range separates the Terai plains from the hill and mountain zone with two distinct physiographic zones, not an arbitrary border in the continuum, but rather forming an upper terrace in the longitudinal ecological zone.

The hill and mountain zone is much more diverse in physiography than the Terai plains. As the elevation increases from the south to the north, the physiography comprises of the River Kali

terraces, the ridges and spurs of the main Mahabharat range, the River Seti terraces, the gradually elevated foothills of the main Himalayan range, the massif uninhabited Himalayan range, an inner Himalayan valleys located between the main Himalaya and the Tibetan Plateau, and the foothills of the Tibetan Plateau (figures 1 and 2 for the profile of the cross-section).

INSERT FIGURE 2

Soil characteristics vary according to topography and elevation, and soil profiles follow the pattern of the ecological zones (Tiwari, 1998).

Climatic features also are influenced by topography and elevation. The temperature remains rather low raning from 5-15^{0}C throughout the year in the north, but its variation is very high in the south, ranging from 5-25^{0}C in winter to 20-35^{0}C in summer. Annual rainfalls vary between 1,000 and 3,500mm, increasing from the south to the north, with some exception in the rain shadow areas of the north facing slopes. The inner Himalayan valleys which are rain shadow areas, receive rain of less than 1,000mm (Tiwari, 1998).

To understand the relationship between the ecological variation and agricultural production, it is also necessary to understand the provisions of basic infrastructure in each zone. Given the topographical difficulties in Nepal, "accessible" places are defined, in this study based on the survey result, as those located within a distance of one hour walk from a road. Places beyond this distance, but within a walking distance of four hours, assuming that one can commute to the road and/or market center and return on the same day, are defined as "commutable". Places farther away than this travel distance are defined as "remote". Based on these definitions, in the hill and mountain ridges, only one settlement is accessible; about 40% are commutable; and almost 60% are remote. The hill and mountain valleys are better off in terms of accessibility, where 30.5% of the households are accessible, 39% commutable and 30.5% remote. In the Terai plains, more than 60% of the households are located in accessible and the remaining in commutable villages. Thus villages range from exclusive settlements located in remote areas without any modern means of transportation facility, access to market, or provision of services to settlements located in accessible areas with modern means of transportation facilities and easy access to markets and provisions of economic services.

Electricity and irrigation, which are among the most important input of agricultural modernization, also have not been introduced in the hill and mountain ridges except for some micro-hydro/solar power generation in a couple of settlements. However, in the hill and mountain valleys, about 40% of the households have access to at least one facility, whereas in the Terai plains, more than 90% of the households have the benefit of utilizing at least one of these facilities. This shows that as topography becomes more complex, despite greater population concentration in such areas, provisions of facilities decrease. Provisions of infrastructure facilities as well as accessibility to those facilities and basic socioeconomic services have been considered as the contributory factors to the decision-making for crop production.

3. Results and discussions

3.1. Farm lands

Most arable land in Nepal was farmland, except for some patches of arable land covered by permanent forest in the Terai plains and some community land at the center of some villages. According to the available computation, 26.5% of the total land was under agriculture (National Planning Commission 1992a; quoting LRMP Land Utilization Report, 1986). To acquire land for crop production, people in Nepal have carved even stiff slopes and constructed terraces. They have also consolidated banks of streams and rivulets and extended their fields alongside. In this connection, the total size of land holding, plot size as well as nature and quality of land is a major concern to farming, which are discussed in this section.

3.1.1. Size of landholdings and its distribution

In Asia, land is the most important factor of production, a reliable investment and a symbol of power. Moreover “land is the pivot around which the rural subsistence economy clusters”. In Nepal, like in most non-communist countries in Asia, land is the single natural resource which is held in private ownership. It is therefore the size of landholdings and its distribution have a great role in the crop cultivation system in Nepal. This study showed that 98% of the sampled households had some land.

The landholding size ranged between a minimum of 0.05 hectares and a maximum of 7.00 hectares. The average landholding size was about one hectare per household, and a corresponding per capita was 0.145 hectare, with a standard deviation of 0.127 hectare.

A significant variation in the distribution of landholding size was observed among households across ecological zones, with an observed per capita landholding size of 0.131, 0.136 and 0.182 hectare for hill and mountain ridges, hill and mountain valleys, and Terai plains respectively.

Gini coefficients applied to measure differences between class intervals. They were 0.367 for the hill and mountain ridges, 0.356 for the hill and mountain valleys and 0.454 for the Terai plains. These coefficients revealed a wider differentiation in the plains than in the ridges and valleys.

Since almost all farmers were small in practical terms, a large-scale extensive, commercial farming with farmers' own farm-infrastructure was out of question. An intensive farming was, thus required to sustain their livelihoods. Similarly, as the ecological complexity increased the size of landholdings decreased. It would contribute to determine the pattern of crop cultivation in the three ecological zones.

3.1.2. Fragmentation of landholdings

Not only the landholding was small as presented above, but also it was typically divided into tiny plots. The minimum number of farmland plots was one and the maximum was 33. The average number of plots was 5.4, with a standard deviation of 3.9, which confirmed a severe fragmentation of landholidngs in Nepal. The distribution of numbers of plots slightly correlated with the distribution of landholding size. This was confirmed by the coefficient of correlation of 0.23, which was statistically significant at 0.01 level. The variation on the number of plots across the three ecological zones varied significantly. Households in the hill and mountain valleys held the largest number of plots, i.e., six plots on average, whereas the smallest average of 3.8 plots was held by households in the Terai plains. It confirmed fragmentation of landholdings somehow a situation created by the ecological complexity as well.

Fragmentation of landholdings happened for four reasons. First, land holding was divided from the household head who posses the land normally the man, to his wife/wives and son(s) upon his death or legal separation of these shareholders. At this time, most plots were equally divided among the shareholders, reflecting an equal share by quality of each plot. Secondly, the subsistence farming practice required at least four plots which can be ideal to produce (i) paddy, (ii) corn, millet and dry-paddy, (iii) cultivation of minor crops like taro, beans, and legumes, and (iv) thatch grass. Thirdly, since land is considered as a single most important resource, a reliable investment, and a symbol of power, farmers while buying a new piece of land, neglected the increased number of plots. And fourthly, particularly in the two hill and mountain zones, there are small patches of arable lands within forest, fallow, slopes and cliffs as well as along rivulets and streams. Land consolidation, a measure recommended to overcome fragmentation of landholdings, had been undertaken by only 1.2 percent. Their average number of nine plots was reduced to six after consolidation. Such fragmentation has helped to cause an unique pattern of crop cultivation in Nepal.

3.1.3. Nature and quality of farmlands

In this section the nature and quality of farmlands are discussed, with a view to their impact on agricultural practices. The small size of landholdings fragmented into tiny plots indicates the nature of land. The issue of land quality is related to the sustainability of agriculture. There are actually three ways of measuring the quality of land: (i) the standardized measurement adopted by the Government for taxation and other evaluation purposes, (ii) the identification/measurement of physical characteristics which are suitable for particular plant growth, and (iii) the farmers' evaluation on the basis of their experience while producing various crops and employing certain land improvement measures.

Taking into consideration the first two measures and based on the nature vis-à-vis quality of land for the description and analysis of the cultivation in Nepal, this study has divided farmlands into five types: (i) homestead, (ii) *pakho* (dry-crop land), (iii) *khet* (paddy-land) non-irrigated, (iv) *khet* (paddy-land) irrigated, and (v) orchard/thatch grass/land/forest land. By nomenclature itself the quality of the farmland is diverse. A distribution of per capita landholding size by these types of land by ecological zone is presented in table 2. Statistically significant variations were observed in the

sizes of a homestead and non-irrigated land and irrigated paddy-land across the three ecological zones.

Almost all households in the two hill and mountain zones and 77.1% households in the Terai plains possessed some farmland around their homestead. The *pakho* (dry-crop land) followed by *khet* (paddy-land) non-irrigated was a common phenomenon of farmland in the two hill and mountain zones. Orchard, thatch-grass land, and forest were owned by more that 35% each in the two hill and mountain zones. The *khet* (paddy-land) non-irrigated was the dominating farmland in the Terai plains. In addition, the average size of paddy-land was larger in the Terai plains than in the two hill and mountain zones (table 2). However, dry-crop land and orchard-thatch-grass land were not common in the Terai plains. It is also clear that non of the types of farmlands in the two hill and mountain zones were over 700 sq. m. in size.

Grouping land types into *khet* (paddy-land, both irrigated and non-irrigated) and *pakho* (dry-crop land, including orchard, thatch grassland and forest land), there was a significant variation between the ratio of dry-crop lands to paddy-lands across the ecological zones. In the two hill and mountain zones, the ratio of dry-crop lands was more than double that of paddy-lands, i.e. 2.09 and 2.38 for hill and mountain valleys and hill and mountain ridges respectively. Contrary to it, the ratio in the Terai plains was very low, at 0.67. This has clearly delineated what types of crops farmers would prefer to cultivate based on their traditional farming practices.

Table 2
Distribution of per capita landholding size by type of land and ecological zone (Area in hectare)

Type of Land	Ecological Zone					
	Hill & Mountain Ridges (N=203)		Hill & Mountain Valleys (N=105)		Terai Plains (N=96)	
	f'	Mean	f'	Mean	f'	Mean
Homestead#	99.0	0.02	96.2	0.03	77.1	0.04
Pakho (Dry-land)	77.8	0.07	73.3	0.07	7.3	0.09
Khet (Paddy-land) non-irrigated#	56.2	0.06	43.8	0.07	69.8	0.16
Khet (Paddy-land) irrigated#	14.8	0.07	27.6	0.05	17.7	0.11
Orchard, thatch-land, forest	35.0	0.03	35.2	0.03	8.3	0.02
Total	99.5	0.13	97.1	0.14	96.9	0.18

N = Number of sample households ! f' = Proportion of N

Variance of per capita landholding size by type of land between three ecological zones not significant even at 0.1 level.

The study also analyzed farmers' assessment of the present quality of land. It revealed that 36.1% farmers from hill and mountain ridges, 20.2% from the hill and mountain valleys, and 25% from the Terai plains had experienced degradation, and reported a worsening in the quality of land. Problems associated with quality of land were observed in the old cultivated lands of the Terai plains due to intensive farming and lack of proper management. In the hill and mountain zones, pressure from human and livestock populations caused the worsening of the soil quality, despite practices of traditional soil management.

Despite the above mentioned problems on the quality of land, majority of farmers assessed the quality of land maintained (not degraded) or even improved. Most landholdings in the two hill and mountain zones had not undergone any severe changes over time. Similarly, 32.6% of the farmers from the Terai plans indicated no change in the quality of land.

More than 40% of the farmers in the Terai plains, 31.1% in the hills and mountain valleys, and 26.9% in the hill and mountain ridges had experienced some improvement in soil quality.

Those who had observed improvement in soils had used sufficient manure along with the traditional soil management, like manuring, use of litter, terracing and check-dam construction, *goth* (temporary-shed)/*kila* (weekly sheltering, tying in pillar with rope) i.e, sheltering livestock in

farmlands, and diverting limited *bhal-pani* (early monsoon floods) in farmlands. The farmers' assessment revealed the improvement of land quality with decreasing altitudes from the ridges, through the valleys, to the plains.

The findings of this study, therefore, only partially support the statements of planners and professionals that the quality of land has been deteriorating at a critical pace (Blaikie et al. 1980, p.5; Ives and Messerli 1989; Thapa and Weber 1989). Since operating land purportedly had not severe undergone degradation in quality over the years, the impact of the quality of land on production should not be considered as a serious obstacle. However, apparently to increase farm productivity, there is a need for land quality improvement through scientific interpretation of traditional soil management and farming practices, along with compatible and sustainable modern measures.

3.2. Input use, modernization and sustainability of crop production

The small landholding sizes divided into tiny plots and the diversified nature of farmlands somehow show limitations on the use of modern input and modernization of farming. In the given context of farmland this section discusses input use and modernization with a view to sustainability of crop production in the three ecological zones in Nepal. Extent and intensity of the use of inputs play crucial roles in increasing output and maintaining the quality of land resource. As the complexities on the properties of the land resource increase, such as decrease in fertility and increase in alkaline or acid contents of soils, certain quantities of conventional or modern measures of soil treatment like applying manure, fertilizer, or lime become necessary to maintain the quality of resource. Another equally important one is to increase productivity and alleviate efforts, i.e., easing work while maintaining the quality of the resource.

The study revealed somehow mixed results on the various inputs use in crop production. Table 3 shows households using various inputs in crop cultivation across the three ecological zones.

Table 3
Proportions of households using various inputs in crop production by ecological zone

Inputs Used	Total	Ecological Zone		
		H&MR (N=203)	H&MV (N=105)	TP (N=96)
Modern varieties	28.2	13.8	39.8	53.4
Manure	91.6	95.1	91.4	84.4
Chemical fertilizer	38.1	28.6	41.0	55.2
Traditional plant protection	26.5	28.6	24.8	24.0
Plant protecting chemicals	7.9	5.4	11.4	9.4
Modern tools like iron plow	13.4	8.9	9.5	32.11
Machinery	2.7	-	-	11.5

H&MR = Hill and mountain ridges • H&MV = Hill and mountain valleys • TP = Terai plains
N = Number of sample households

Note: Chi-square values significant at 0.01 level between ecological zones for each input used, except traditional plant protection and plant protecting chemicals.

3.2.1. Improved varieties

The improved varieties of crops were expected to increase production and farmers, despite publicized efforts of government agencies, only 28.2% households used improved varieties (Table 3). If further broken-down by individual crops, maize and summer rice were produced by the largest proportions of households and their cropping areas were also the largest, yet their improved varieties were used by only small proportions of households, i.e. summer rice by 27.6% and maize by 17.5% of all households (table 4). Only wheat and spring rice, which were relatively new crops in most areas, were produced by about 50% farm households each with improved varieties. Improved varieties of major cash crops – sugarcane, potato, fruits and oilseeds – had been adopted by households ranging from 1.5

to 12.5%. Millet, pulses, ginger, forest produce, dry rice, thatch-grass, and vegetables had no improved varieties used.

Table 4
Production of agricultural commodities across ecological zones

Crops	Area (ha)	Proportion of Households producing each crop (N=400)		Proportion of households using improved crop varieties	Proportion of households producing each crop		
		n	n'		Hill and mountain ridges (n=199)	Hill and mountain valleys (n=98)	Terai plains (n=86)
Summer rice	0.754	315	78.0	27.6	76.9	81.6	85.3
Maize	0.471	325	80.4	17.5	99.0	98.0	36.8
Wheat	0.457	183	45.3	48.1	28.6	56.1	82.6
Spring rice	0.279	55	13.6	50.9	14.7	25.8	1.1
Millet	0.273	242	59.9	-	86.4	66.3	7.0
Pulses	0.227	290	73.8	-	77.4	72.4	75.6
Ginger	0.156	82	20.3	-	13.6	3.1	0.0
Fruits	0.154	74	18.3	6.8	19.6	37.1	7.5
Oilseed	0.146	205	50.7	1.5	44.7	42.9	86.0
Forest produce	0.140	20	5.0	-	6.0	7.1	1.2
Dry rice	0.129	124	30.7	-	36.0	55.8	0.0
Sugarcane	0.110	24	5.9	12.5	2.0	10.2	11.6
Thatchgrass	0.068	30	7.4	-	28.1	24.5	2.4
Potato-yam-taro	0.055	273	67.6	8.1	71.7	75.3	67.4
Vegetables	0.050	146	36.1	-	29.3	38.8	60.2
Other crops	0.104	20	5.0	-	8.5	2.0	1.2

Note: n = number of applicable sample households
Figures are proportions of n.
Variance of the production of potato-yam-taro, pulses and forest products across ecological zones not significant even at 0.1 level.

While exploring varieties across ecological zones, households using at least one improved variety were just 13.8% in the hill and mountain ridges, about 40% in the hill and mountain valleys, and more than 50% in the Terai plains (table 3). This variation was statistically significant. Despite spatial variation in the use of improved varieties, any substantial impact of green revolution or any area-specific changes in crop production has not been taken place.

Ironically, the majority of farmers were not using any improved varieties of crops, albeit their potential of increasing production. This is largely due to the fact that a large proportion of farmers had not been well informed about the varieties of crops that could thrive well in their farmland and suit their farming conditions. Whichever variety they were well aware of, the reasons given for not adopting such varieties included yield not reliable, seed not available, requiring much labor, lack of irrigation, no use by neighbors either and sensitive to disease. These reasons highlighted the poor reliability of the crops, i.e. uncertainty about a reliable yield, and unlikely resistance to diseases, deficiencies in support services and infrastructure, high labor requirement, and poor information dissemination.

Deficiencies in support services and infrastructure emerged ranking high as reasons for not using any improved crop varieties. Other major reasons for not using improved varieties by farmers in the hill and mountain zones were requirements of much labor, not being well informed of such varieties, seed not available, and yield not reliable. Among the farmers in the Terai plains, who were

not using particular improved varieties stated that the yield was not reliable as the first reason, followed by not being well informed of such varieties, sensitivity to disease and seed not being available.

Despite some of farmers who identified new varieties of crops either as having a shorter growth period, high yielding, securing a high price, attaining good quality or requiring less labor, the large majority still opted for the continuation of traditional varieties. The study identified eight reasons. The first ranked one was that farmers were encouraged to use traditional varieties first and foremost through examples set by neighbors and the experience of obtaining a reliable yield. The other reasons cited in order of importance were the prospect of producing high quality produce, the high resistance to diseases, their commanding high prices, their requirement of less manure/fertilizer, and less labor.

3.2.2. Use of manure, chemical fertilizer and plant protection inputs

Taking involutionary process into consideration and looking at the use of each individual input in farming, over 80% of households across all ecological zones were using manure, a continuation of traditional practice. However, there remained a significant variation in manuring across the three ecological zones, and it was decreasing from the hill and mountain ridges, through the hill and mountain valleys, to the Terai plains (Table 3).

An alternative and complementary input to manure was chemical fertilizer, which was used by a little less than 40% of the total households. Like manure, its use also varied across ecological zones, but in an opposite trend, i.e. increasing from the hill and mountain ridges downward to the Terai plains. It was used only by just above 25% households in the hill and mountain ridges, 40% in the hill and mountain valleys, and more than 50% in the Terai plains (table 3).

Farmers had given the following reasons for not using any chemical fertilizer: (1) not being well informed of the consequences of using chemical fertilizer; (2) neighbors are not using it either; (3) sufficient manure available; (4) expensive/unaffordable; (5) suspicion about creating problems on the farm; (6) not profitable and (7) unavailable in time of need. The same reasons prevailed among households in the hill and mountain ridges. The ranking of the reasons, however, differed in other two zones. Farmers from the hill and mountain valleys, however, ranked neighbors not using it either, availability of sufficient manure and not being well informed as the first three reasons for not using chemical fertilizer. Farmers from the Terai plains ranked availability of sufficient manure as the first reason, followed by not being well informed and creating problems on the farm. Availability of sufficient manure at one's own farm was not a deficiency, rather it has been recognized as a component that is conducive to sustainability. It would reduce cost of farming as well. Two economic reasons, expense and/or affordablility, and unprofitability, which were basically faced by small farmers, were restraining the wider use of chemical fertilizer.

Another problem that some had experienced and others had perceived from hearsay was the degradation of soils. Its implication for the use of chemical fertilizers would be strongly negative, unless its proper use and beneficial effects were clarified to both, user and nonuser groups of farmers.

However, the other two higher ranked reasons cited by farmers across all ecological zones stemmed from the fact that demonstration and extension services were severely lacking across the ecological zones of Nepal.

Another input equally important to increase production, yet maintaining soil fertility intact was plant protection input. *Pati* (*Artemisia vulgaris*), *asuro* (*Adhatola vasica*), *khirro* (*Sapium insigne*), other numerous bush plants, and litter from specific plants were biological means used to treat soils. Smoking farmlands and inter-cropping were done to control insects and pests. Although majority of the farm households did not use this input, it was yet widely used over plant protecting chemicals, constituting 26.5% and 7.9% respectively. Elsewhere, in areas where the green revolution has made an impact, the traditional plant protection measures have now been replaced by pesticides and insecticides. In the study area, however, only 11.4% farm households were using plant protecting chemicals at its maximum, in the hill and mountain valleys (table 4). Unlike manure and fertilizer use, significant usage of the traditional or modern plant protection inputs did not vary across the ecological zones.

3.3.3. Use of improved tools and machinery

Use of improved tools and machinery was the fourth input, that eased farmers' drudgery, saved time, and helped to improve quality of work. Use of such modern tools such as an iron plow was used only by 13.4% of the total farm households and machineries such as a tractor, power-tiller, threshers were used only by 2.7%. Their use was significantly varied across the three ecological zones. Use of tractor, power tiller, thresher or any other mechanical implements was absent in the two hill and mountain zones. The use of modern tools like iron plow observed decreased as the terrain becomes complex, i.e., from the Terai plains to the hill and mountain ridges. In other words, the diffusion of the modern tools was restrained by terrain complexities, i.e. decreasing the use of modern tools in an increasing the ecological complexities. This confirmed that only the early acceptors have embarked on the process of modernization. It was certainly not only the time element that accounted for the late majority in not going along with farm modernization, but also there were some other underlying reasons which restrained individual households to use modern inputs. These are discussed in the following section.

Problems associated with the low level of adoption of modern tools like the iron plow were identified as caused by not being well informed, incompatibility with farm operations, neighbors not using them either, higher cost than traditional tools, too small plot size and time-consuming application. Farmers across ecological zones ranked not being well informed as the first reason. Farmers particularly in the hill and mountain ridges and hill and mountain valleys found the known modern tools incompatible with their farm operations. Unlike this, the other problem associated with the farmers in the Terai plains was small landholding size, small plot size or small terraces in which particularly the use of a iron plow was less convenient than the use of the traditional wooden plow.

The reasons for not using farm machinery were numerous. The first three were neighbors not using any either, not being well informed and incompatibility with farm operations which were the same reasons given for not using modern tools. Two other reasons, sufficient household labor and cheap hired labor were disincentives. The reasons why farmers were not using any farm machinery were somehow similar to those for not using chemical fertilizer or modern tools.

Adoption and use of high yielding crop varieties along with appropriate use of farm chemicals, and adoption of improved tools along with farm machinery were considered as manifestations of the modernization process in farming, because they tend to increase production and, hence, income. In most villages, there were at least some very early acceptors of innovations who had tested new varieties, farm chemicals and modern tools. They had, however, given up due to discouraging results, as they had not been well informed of the complete package, nor had they observed the correct process of agricultural modernization.

Modernization in farming is actually a package of compatible inputs and support services. Deficiency of one or more renders improper functioning and will not yield the desirable outcome. Except two villages, irrigation was not available in the hill and mountain zones where, therefore, modernization in farming has hardly been realized. The hill and mountain zones lack motorable roads and, thus, are deficient in support services. Although at least one Junior Technical Assistant (JTA) or Junior Technician (JT) was assigned to every two or three village development committees, ordinary farmers particularly in commutable or remote areas were not aware of such extension services. In the remote and commutable villages in the hill and mountain zones, a frequent visit by the farmers to the agricultural research centers located elsewhere or to progressive farms in the vicinity was most unlikely to happen. There were no agricultural exhibitions held in the hill and mountain zones. Radio Nepal broadcasts a half hour regular agricultural program at 6:00 pm. However, majority of the farmers do not have a radio. Those who have a radio the timing does not permit for them to listening it, since it broadcasts during a time when farmers still remain outdoor. Neither, the program has been able to attract the attention of the farmers. The market mechanism, which could also induce agricultural modernization, has very weak forward and backward linkages, and it is unable to propagate modernization in agriculture in Nepal. Thus, diffusion was left to a spontaneous process.

3.3. Crop production

Depending upon the croplands, particularly the holding of *pakho* (dry-crop land) or *khet* (irrigated and non-irrigated flat-lands or terraces where paddy is produced), the complexity of the terrain, the input use and the adoption of innovations by a farmer as discussed above, as well as the existence of

irrigation, rain and moisture conditions in the soil, 16 types of crops, both major and minor were produced in the study area. They include cereal crops - various types of rice, maize, wheat, millet, pulses, oilseeds, roots and tubers– ginger, potato, yam, taro– fruits, vegetables, thatch, forest and other minor crops, including buckwheat, fox-tailed millet, sorghum, *lete*, and amaranth. The types of crops produced by farm households and their corresponding area by ecological zones is presented in table 5 above. In this section, the cropping pattern/system, intensity, diversification/specialization, and productivity are discussed.

3.3.1. Cropping pattern/system

Summer rice was the single crop occupying the largest area, 0.754 hectares on average. The smallest area, 0.050 hectares, was cultivated with vegetables. In terms of household involvement, maize was produced by the largest proportion, 80.4% of all households, followed by summer rice by 78.0%. The smallest proportions were forest products and other rare crops, produced by 5% each. There was significant ecological variation, in the production of the identified crops.

Only three crops, namely, rice, pulses and potato-yam-taro, which constituted the three main food items of rice, dal and vegetables, also colloquially know as *bhat, dal, tarkari* respectively, were common across the three ecological zones. It shows the forms of production in subsistence first. Rice was produced by more than 75% of the farmers in each zone. Similarly, pulses were produced by more than 72.4% and potato-yam-taro by 67.4% of the farmers in each zone.

In addition, two crops, maize and millet, were common in the two hill and mountain zones, and wheat was common in the hill and mountain valleys and the Terai plains. In the Terai Plains, wheat was the second crop produced in *khet*, along with oilseeds and pulses. Although wheat and oilseeds could be produced in any type of farmland, the lack of even a single occurrence of irrigation or insufficient rainfall discouraged their production in the hill and mountain ridges. Production of various crops in order of proportion of households from high to low, the across three ecological zones is given in table 5.

Table 5
Production of various crops in order of proportions of households across ecological zones

Area	Proportion of households producing each crop			
	Total Households	Hill and mountain ridges	Hill and mountain valleys	Terai plains
Summer rice	Maize	Maize		Oilseeds
Maize	Summer rice	Millet	Summer rice	
Wheat	Pulses	Pulses	Potato-yam-taro	Wheat
Spring rice	Potato-yam-taro	Summer rice	Pulses	
Millet	Millet	Potato-yam-taro	Millet	Potato-yam-taro
Pulses	Oilseed	Oilseed	Wheat	Vegetables
Ginger	Wheat	Dry rice	Dry rice	Maize
Fruits	Vegetables	Vegetables	Oilseeds	Sugarcane
Oilseed	Dry rice	Wheat	Vegetables	Millet
Forest produce	Ginger	Thatchgrass	Fruits	Fruits
Dry rice	Fruits	Fruits	Spring rice	Thatchgrass
Sugarcane	Spring rice	Spring rice	Thatchgrass	Forest produce
Thatchgrass	Thatchgrass	Ginger	Sugercane	Spring rice
Potato-yam-taro	Sugarcane	Forest produce		-
Vegetables	Forest produce	Sugarcane	Ginger	-
Other crops (not in order)				

In total, five crops in the hill and mountain ridges, seven crops in the hill and mountain valleys, and six crops in the Terai plains were produced by majority of the farm households, i.e. over 50% each (see table 4 for the proportion of each crop and table 5 for their order in each zone which is shown by dark-shading). Beyond the three common crops rice, pulses and potato-yam-taro as mentioned above, other crops included maize and millet in the hill and mountain ridges, maize, millet, wheat, and dry rice in the hill and mountain valleys, and oilseeds, wheat and vegetables in the Terai plains.

In fact, most households grew vegetables like chilly, brinjal, pumpkin, okra, and various types of gourds in summer and leafy vegetables, radish and tomato in winter. However, they were numerous, their cropping areas and yields were so small that most farmers did not count them at all, although this production was also for consumption and met large proportion of their requirements of vegetables. Moreover, absence of vegetables from the essential foodstuff on the one hand, and the lack of a market for fresh vegetables in the village on the other hand, were the two underlying causes of their limited production in the two hill and mountain zones, unlike in the Terai plains.

Spring rice, ginger, fruits, forest produce, dry rice, sugarcane and thatch-grass were not among crops produced by majority of farm households in any ecological zone. However, their production was varied across ecological zones (see table 4). Some other crops, which were not produced by majority, were produced by more than a quarter of the total farm households. This constituted oilseeds and dry rice in the hill and mountain ridges, oilseeds, vegetables, fruits, and spring rice in the hill and mountain valleys, and maize in the Terai plains, which are also shown in table 5, using light-shading.

Given variation on the major types of farmland and corresponding suitability to farming, three major systems of crop production emerged in Nepal, which are as follows.

(1) *A dry-land cropping system* of the maize-millet group of crops in the hill and mountain ridges.
(2) *A wet-land cropping system* of rice-wheat group of crops in the Terai plains.
(3) *A combination of the above two systems* of crop production in the hill and mountain valleys.

From the analysis of the crop production, the following five specific patterns based on agro-ecological entities were identified.

(1) *Production of certain crops decreased as the spatial complexity increased*, i.e., decreased from the Terai plains, through hill and mountain valleys, to the hill and mountain ridges. These were wet-land crops and the lack of the provision of irrigation and the difficulty with construction of flat terraces to hold rain water as terrain complexity increased clearly reflected their presence. Two major wet-land cereal crops, summer rice and wheat, and two cash crops (sugarcane and vegetables) were included in this pattern.
(2) *Production of certain other crops increased as spatial complexity increased*, i.e., from the Terai plains, through the hill and mountain valleys, to the hill and mountain ridges. This was a group of dry-land crops. As the intensity of wet-land crops decreased along with spatial complexity, the intensity of this group of crops increased, reflecting the simple ecological niches. Two major dry-land cereal crops—maize and millet—one newly emerging cash crop (ginger), and a category of other crops fell in this pattern.
(3) *Crops that have no trend along the change in spatial complexity or simplicity or agro-ecological change.* Two basic foodstuffs which are also major cash crops, pulses and potato-taro-yam and fruit produce fell in this pattern.
(4) *A fourth group of crops which were prominent in the two hill and mountain zones* (hill and mountain ridges and hill and mountain valleys) and almost nonexistent in the Terai zone. Crops included in this pattern were spring rice, fruits, dry rice, and thatch-grass. Spring rice was produced in patches where irrigation was feasible through rivulets. Dry rice was supported by temperature and could be planted with maize, and harvested well before the time to produce the following crops of millet, pulses, or potato. Similarly, fruit production was supported by drained soils, relatively high temperature, and availability of parcels of land which may not be suitable for cereal crops yet ideal for fruit crops. Thatch-grass was produced as the major roofing material and fodder in remote areas, where slate was not easily available, and tin was less affordable. Thatch-grass could also thrive in poor or marginal lands which were becoming abundant as the terrain became more complex.

(5) A fifth group of crops which were produced by majority farmers in the Terai zone and by more than 40% of the households in the two hill and mountain zones. Oilseed has fallen under this pattern.

Forest produce did not fall into any category. It is because it was produced by some very small numbers in all zones. Until few years back, forest was completely under the Government control, and production of trees was out of question. Now forest-farm can be owned by individuals. Since almost all small patches of forests have been transferred to communities, except few farm households who have started forestry in their thatch-lands and forest-lands, farmers so far have not significantly changed their traditional farmlands to forestry.

Remarkably, this system of crop production was not compatible with the agricultural zoning with a focus on specialization in livestock rearing in the northern region, horticulture development in the central hills, and food grains and cash crops production in the southern plains of the country as stipulated from the Fifth Plan (National Planning Commission, 1975).

3.3.2. Cropping intensity

Given the small farm size and a large proportion of household labour force engaged in farming, a very high cropping intensity was expected, because of cropping intensity being a process of efficient utilization of limited land resources for higher production by doubling or tripling crop cultivation within a year, in a plot or a part of a plot of land. There was no standard cropping intensity index for any economy related to a particular area. However,, according to the nature of crop, farmers could theoretically grow more than six crop-hectare per hectare of land, if a cropping period like that of mushroom or some leafy vegetables, was about six weeks and as below as one hectare-crop, if a cropping period is as high as nine months like that of sugarcane. Farmers in this region were producing 1.72 hectare-crop per hectare of landholding. The cultivated area, cropping area, and cropping intensity across ecological zones is given in table 6. The cropping intensity values for hill and mountain ridges, hill and mountain valley, and the Terai plains were 1.71, 1.76 and 1.69 respectively. This showed some higher intensity value for the hill and mountain valleys, the variation of cropping intensity across the three ecological zones was not statistically significant.

Table 6
Cultivated area, cropping area and cropping intensity across ecological zones

Indicators	Overall	Hill and mountain ridges	Hill and mountain valleys	Terai plains
Household number	404	203	105	96
Cultivated area (hectare)	0.97	090	0.82	1.27
Cultivating households	383	199	98	86
Cropping area (hectare)	1.59	1.44	1.44	2.08
Cropping intensity	1.72	1.71	1.76	1.69

The marginal and small farm households despite their very small landholding sizes, tried to cultivate all the major and minor crops in their few farm land-plots. This was a strategy of subsistence agriculture to fulfill household requirements. The large farm households, on the other hand, with larger numbers of farm land-plots, diversified their cultivation according to land suitability and location of plots. The emerging cropping pattern, thus, played an important role in determining the cropping intensity. Regular crops in two seasons, maize in Spring and millet in Summer were produced in *pakho*, followed by at least leafy and tuber vegetables, potato-taro-yam, pulses, some mustard, few lumps of sugarcane and a single or few fruit trees, the latter particularly in the homestead plot. Since almost every household was situated in a *pakho* homestead plot, this contributed to a pattern of proportionately larger *pakho* areas among smaller farms; hence, their cropping intensity appeared to be higher. On the other hand, farmers produced only one crop of rice in

the most non-irrigated paddy farms. The proportion of such farms was large among medium and large farmers, and their cropping intensity remained lower. Overall, farmers produced rice, or wheat in distant plots of *khet*, and maize, dry rice, and millet in distant plots of *pakho.* Relating cropping intensity to efficiency of land uses therefore was not the case in Nepal.

3.3.3. Crop diversification or specialization

Analysis of crop diversification or specialization was done to understand the orientation of crop production for subsistence or market. Given the nature of farmlands, numbers of farm-plots, cropping pattern, and cropping intensity, however, a very specialized crop production practice was not expected. On an average, farmers were producing six crops per year, and range between three and nine crops normally. Table 7 shows the mean and corresponding standard deviation values for the three ecological zones, with the average number of crops produced ranging between 6.33 (Terai plains) and 7.11 (hill and mountain valleys).

Table 7
Number of crops produced and index of crop diversification across the three ecological zones

Crop diversification	Total (n=384)		Hill and mountain ridges (n=199)		Hill and mountain valleys (n=98)		Terai plains (n=87)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Number of crop produced	6.53	2.38	6.39	2.47	7.11	2.56	6.33	1.43
Index of crop diversification	18.26		18.76		16.48		19.14	

An index of crop diversification was computed using an Index of Crop Diversification (ICD) formula [15] which has been taken from Thapa and Weber (1990, pp. 129, quoting Bhatia 1965). The resulting index value of 18.27 confirmed that there was a high crop diversification in this area. The indexes of crop diversification or specialization ranged between 19.14 (Terai plains) and 16.48 (hill and mountain valleys), with no statistically significant variation between the three ecological zones.

Several correlations were computed to further analyze the diversification or specialization of crop production. The coefficient of correlation between the size of a landholdings and the number of crops produced at 0.1278 showed a weak positive linear association. This relationship, however, was statistically significant at 0.01 level. Also, there were slightly positive linear relationships between number of crops produced and per capita landholding size as well as total number of farmlands plots. The coefficients of correlation were 0.238 and 0.318, respectively, both significant at 0.001 level.

The coefficient of correlation between the number of crops produced and the value of farm produce sales at 0.2492 showed a significant linear positive relationship. Moreover, the coefficient of correlation of 0.4989 indicated a substantial relationship between the number of farm crops produced and months for which food sufficiency was ensured. This leads to conclude that crop diversification was mainly oriented toward household food self-sufficiency, which was the main farming practice across the three ecological zones in Nepal.

[1] ICD = $(P^a + P^b + \ldots\ldots P^n) / N^c$

where,

ICD = Index of crop diversification

P^a = Proportion of sown area under crop a

P^b = Proportion of sown area under crop b

P^n = Proportion of sown area under crop n

N^c = Number of crops

Results obtained would be interpreted as the lesser the index value, the higher is the crop diversification.

3.3.4. Crop productivity

To identify the level of productivity, the yields of major crops by major producers were compared (table 8). Yields of the most important cereal crops – rice, wheat, maize, pulses – and other cash crops, together with potato and sugarcane, were far below world, U.S.A., and Asian standards. However, the yield of millet was substantially higher as much as half the highest yield.

Table 8
Comparison of yields of major crops by major producers (Yield in kg per hectare)

Crops	Yield by Major Producers						
				Nepal		Highest Yield	
	World	USA	Asia	Overall	Study Area*	Amount	Country
Cereals							
Rice	3823	6354	3824	2409	2403	10269	Australia
Wheat	2624	2907	2520	1635	1356	8031	Ireland
Maize	4395	8439	3886	1697	1586	17623	Kuwait
Millet	777	1500	949	1200	1565	3500	Spain
Pulses	837	1849	728	696	624	3957	Denmark
Cash							
Potato	16470	38403	14843	8997	2998	49091	Bosnia Hergz
Sugarcane	64423	80237	62281	36720	32303	136515	Peru

* *Primary survey*.

Sources: FAO, FAO Production Yearbook. FAO Statistics Series No. 148, 1998 (for other than the study area compiled by the author).

The study area had relatively higher yields than the national averages, with the exception of maize and root crops (table 8). There were, however, no significant variations in the yields of summer and spring rice, potato-yam-taro, pulses, fruit and thatch between the hill and mountain ridges, hill and mountain valleys, and the Terai plains (table 9). Rice was one of the major crops in all ecological zones for which people put their best efforts into producing the highest feasible yield. Wheat had become a major crop of the winter season. Its yield varied across the ecological zones, although the level of significance was 0.05. The yield of wheat per hectare was the highest in the hill and mountain valleys, followed by the hill and mountain ridges.

Table 9
Yields of major and minor crops by ecological zone (Yield in kg per hectare)

Crops	Ecological Zone			Average
	Hill & Mountain Ridges	Hill & Mountain Valleys	Terai Plains	
Summer rice#	2255	2609	2484	2403
Spring rice#	1129	1007	-	1056
Dry rice	1696	1244	-	1493
Maize	1869	1194	1019	1586
Wheat@	1288	1712	1144	1356
Millet	1550	1101	2169	1565
Potato-yam#	2822	3568	2539	2998
Pulses#	623	718	514	624
Oilseeds	409	629	932	689
Vegetables	2308	1696	4677	2940
Ginger	6896	3672	-	6383
Fruit#	6332	6269	-	6304
Sugarcane	-	41089	22173	32303
Thatch-grass#	3653	3984	-	3751

 # Variation between ecological zones not significant even at 0.1 level.

@ Variation between ecological zones significant only at 0.05 level.

The crops that varied most in terms of their yield across ecological zones were dry rice, maize, millet, oilseeds, vegetables, ginger, and sugarcane (table 9). Except maize, sugarcane and a very small proportion of oilseeds, other crops were exclusively of the traditional varieties. Although one may not conclude that the use of improved varieties could render substantial boosts in productivity and reach to close to some international standards across ecological zones, there was a relatively high degree of ecological similarity among the improved crop varieties, while rice was largely of the traditional ones. As found out while analyzing the input use, a complete package of green revolution was not available in the area or not accessed to farmers, productivity has remained stagnant or simply increased at its spontaneous pace.

3.4. Livestock rearing and produce

Livestock goes side by side in any subsistence rural economy. So was the practice in the study area. Six major livestock species, buffalo, draft animal, goats-sheep, fowl, cattle and pig were reared in the region. Buffaloes, draft animals, goats-sheep, and fowl (chicken/duck/pigeon) were reared by over 60% of all households. Cattle were reared by more than 40% and pigs by only 25% of all households. Grouped as ruminants (buffalo, cattle, and goat-sheep) and scavengers (pig and fowl), the former was reared by 91.3 % and the latter by only 68.1% (table 10). Until recently, due to religious and traditional sanctions or taboos, the vast majority of Brahmin and Chhetri castes households did not rear any chicken, whereas pigs were reared even by smaller population subgroups. The nature of subsistence practice is also reflected by the size of livestock reared by individual farmers. The minimum livestock size reared of each type was only one head. The largest herd of one type of livestock was 70 sheep, owned by one household in an inner Himalayan village. The second largest size was fowl (50), followed by buffalo (30), cattle (27), pig (9) and oxen/draft-animals (7). Similarly, the combined maximum number of ruminant was 82 and scavenger 50. The size of each specie of livestock indicated that livestock rearing was not in large-scale commercial basis rather a subsistence one. Particularly, the size of fowl which included poultry, clearly showed that there were no even of the early commercialization of livestock, since poultry was the easiest and choice of early innovators for commercial livestock rearing.

There was no significant variation in the distribution of buffalo, cattle, pig, fowl, and combined herd of scavenger livestock rearing over the three ecological zones. There was, however, variation in the distribution of draft animals, goats-sheep, and combined herds of ruminant livestock. The size of draft animal herds was largest in the Terai plains. In contrast, the size of goat or sheep herds were largest in the hill and mountain ridges, followed by the Terai plains and hill and mountain valleys. In fact, the sizes of buffalo or cattle and ruminant livestock reared diminished from the hill and mountain ridges through the valleys to the Terai plains. (see table 10).

Table 10
Households Rearing Livestock and Size of Herds by Ecological Zones

Livestock Species	Ecological Zone							
	Total (N=404)		Hill & Mountain Ridges (N=203)		Hill & Mountain Valleys (N=105)		Terai Plains (N=96)	
	Percent	Mean	Percent	Mean	Percent	Mean	Percent	Mean
Buffalo#	68.3	2.6	72.4	2.7	81.6	2.6	46.9	2.1
Draft animal	66.6	2.0	74.9	2.0	63.1	1.9	52.2	2.5
Fowl#	64.4	7.6	77.3	7.3	62.1	7.0	40.6	9.7
Goat/Sheep	59.4	6.0	70.4	6.9	60.2	4.5	36.5	4.9
Cattle#	42.1	4.3	45.8	4.7	35.9	4.0	47.8	3.8
Pig#	25.0	1.8	32.5	1.9	23.3	1.6	11.5	1.4
Ruminant	91.3	9.3	93.6	11.1	96.1	7.8	83.3	6.9
Scavenger#	68.3	7.8	80.3	7.8	68.9	6.9	42.7	9.6

N = Number of sampled households.

 # Values not significant even at 0.1 level.

Although there is a land titles specifying "grazing-land" in the official land ownership document, such land existed only in the inner or outer Himalayan ranges in the Central and Eastern Regions of Nepal. In the Western Region, there are relatively larger areas of public fallow or forest lands in the hill and mountain ridges and valleys. These lands provided easy access to grazing lands, which facilitated to rear livestock herds. Where farmers had larger size of herds such facility was one of the main contributors. Ironically soil degradation was higher in these places and patches of forests were cleared due to overgrazing and over-collecting of fodder.

In particular, buffaloes, cattle, goats and sheep were reared in community herds in the inner Himalayan zone and in the outer Himalayan range. These herds were reared in remote areas above the altitude where permanent settlements exit. A few members of the community were assigned to take care of the livestock. Their remunerations for subsistence were in kind, i.e., a proportion of livestock or one newly born head of livestock.

The pattern of livestock distribution showed a small positive linear association between farmsize of a household and number of ruminant livestock reared. This was confirmed by the coefficient of correlation, 0.3806, significant at 0.001 level. A large farm plot was not necessary to rear a large herd of livestock since public grazing land was available on those aforementioned villages. Nonetheless, the fodder supply was largely provided by farm produce. Rearing large herds of livestock requires a relatively large and risky investment, which was only affordable to large farm households. Such large farms could easily allocate the required labor, despite their large landholding. These findings further signify the subsistence nature of livestock rearing along with farming across all ecological zones.

4. Conclusion

The study was done with a view to analyze and explain the ecological variations on crop cultivation and livestock rearing in Nepal, with an empirical data from the Western Development Region. The study showed that almost all rural households own land, yet very small size, and divided into numerous small/tiny plots, both of which had a significant variation across ecological zones. There was also a tendency of decreasing size of land holding in increasing ecological complexity, i.e. from the Terai plains through hill and mountain valleys to hill and mountain ridges. So was the tendency of the availability of the perceived better quality of paddy-land, and inversely the dry-crop land. The farmer's assessment on land degradation increased as ecological complexity increased and land quality improved as ecological simplicity increased.

Farmers in such state could practice a highly intensive modernized commercial farming, but they were practicing intensive yet subsistence farming, based on local circumstances. Traditional farm management, basically with manuring and plant protection had maintained to keep soil quality, crop production and productivity intact, which had again the increasing tendency as ecological complexity increased. Degree of intervention in the name of introduction of improved varieties, the use of farm chemicals (fertilizer, pesticides, insecticides, etc.), modern tools, and farm machineries as well as extension services had limited contribution in overall crop production, and whatever impact it was with a decreasing impact with increasing ecological complexity. The ecological complexity was not only reflected on the decreasing size of land holding increasing fragmentation, as well as increasing degradation and decreasing any quality improvement, but also it was a clear obstacle to the so-called diffusion of agricultural modernization.

Since common modern farm inputs had tendencies of decreasing in diffusion as ecological complexity increased, and there were no appropriate local inputs, farmers were bound to continue using the traditional varieties, traditional soil management and treatment and traditional tools, with deficiency of support services and market access, farming practice remained subsistence oriented with the practices what were traditionally used to be.

Consequently, the cropping patterns varied reflecting the impact of agro-ecological variation with a dry-land – a combination of dry-land and wet-land – wet-land cropping systems, and a tendency of declining following the hill and mountain rides, hill and mountain valleys and the Terai plains, or a tendency of inclining following vice versa. Five patterns of ecological entity-based crop production, which prevailed in the three zones, were neither guided by the market demand nor as designated by the National Planning Commission, rather were clear reflection of ecological impact. This concluded the failure of intervention through planning to the zoning of crop production to

increase production and productivity in the three ecological zones, particularly in the hill and mountain zones in Nepal, rather confirmed the continuation of the 'subsistence first' approach of the farm households.

A tendency of no variation on cropping intensity, crop diversification, crop specialization or crop productivity of the major common crops across the three ecological zones demonstrated a no effect of market function on land use and cropping system. Accordingly, the hill and mountain zones tended toward diversification and the Terai plains toward specialization indicated a tendency towards food self-sufficiency and commercialization, respectively.

Livestock rearing which went side-by-side in this subsistence farming system, despite some religious and traditional sanctions and taboos, a tendency of significant variation of the combined herds of ruminant livestock with decreasing number from the hill and mountain ridges through hill and mountain valleys to the Terai plains demonstrated a complementarity to crop production and earning some cash which is very essential to the subsistence economy, and strengthening the subsistence first approach of the farm households.

If cropping practices and livestock rearing have to be changed towards more commercialization, attaining higher production and productivity it is necessary to increase the awareness of the farmers on the modernization of farming and livestock rearing, make farm inputs available to the farmers, provide access to market and support services. For this, a micro-level intervention specific to particular ecological niches is required which should mainly focus on avoiding the barriers emerged from the ecological complexity, as well as suggesting (if there are any existing) and developing inputs and tools suitable to mountainous farming system. Alternatively, and more important, introduction of new and diversified crops, which would yield more profit to farmers, would eliminate the negative impacts of the ecological complexities in the Nepalese farming and livestock rearing.

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