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Strategies for Sustainable Mountain Agriculture in the Middle Hills of Nepal

CASE STUDY

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Preface

The Mountain Farming Systems' Division at ICIMOD, with support from the Asian Development Bank and the Ford Foundation, commenced work on strategies for sustainable mountain agriculture in the countries of the Hindu Kush-Himalayan Region in 1988. Focussing on the imperatives of mountain characteristics such as inaccessibility, fragility, diversity, marginality, human adaptation mechanisms, and 'niche', a conceptual framework called the Mountain Perspective Framework was developed. This help assess the sustainability implications of public policies and programmes for mountain agriculture.

Using the same framework, attempts were made to examine farmers' production and resource management practices, their adaptations to the aforesaid specific mountain conditions, and their responses to development interventions. This was done through field studies of various farming systems in selected areas of China, India, Nepal, and Pakistan.

The focal issue emphasised, in reviews of both agricultural policies and programmes and farmers' practices and responses, was the degree of match or mismatch between attributes of public and private (i.e., farmers') interventions in mountain areas, on the one hand, and imperatives of mountain conditions, on the other. This could serve as a first step towards assessing the sustainability implications of present resource use patterns in mountain areas. The major findings based on the above work are available through an ICIMOD publication entitled 'Sustainable Mountain Agriculture'[1].

Detailed versions of the empirical material synthesised and incorporated by the above publication are disseminated separately. A major part of this material is comprised of studies of farmers' strategies in selected areas: West Sichuan (China), Chitral (NWFP, Pakistan) Himachal Pradesh (India), and the Middle Mountains of Nepal. Conducted from 1988 to 1990, these field studies focussed on the current status and emerging directions of mountain farming systems. To cover broadly different agro-ecological situations, three types of farming systems were studied. They included (i) an annual crop-dominated farming system, (ii) horticultural crop-dominated farming system, and (iii) livestock-dominated farming system. Despite demographic, cultural, and socioeconomic differences among different countries these types of farming system showed considerable similarities, especially with reference to emerging unsustainability scenarios as a result of rising pressure on mountain resources.

It can be added that these studies sponsored by ICIMOD and conducted by national experts from the respective countries are not strictly uniform in terms of descriptive coverage of issues and depth of analyses. They are published as such with necessary language editing.

This report provides details on the farming systems in the Middle Hills of Nepal.

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[1] N.S. Jodha, M. Banskota, and Tej Partap (eds). *Sustainable Mountain Agriculture,* Vol. I - Perspectives and Issues, Vol. II - Farmers' Strategies and Innovative Approaches. Delhi: Oxford & IBH Publishing Company (P) Ltd., 1992.

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INTRODUCTION

Background

Agricultural development in Nepal started formally in 1956 with the formulation of the first periodic five year plan. However, based on the resource allocation pattern, the agricultural sector has been accorded the highest priority among all the sectors of the Nepalese economy from the Fourth Plan (1970-75) onwards. More than one-third of the total financial resources of the plan are allocated to this sector. Although various research innovations and their adoptions have taken place in the Kingdom, the overall agricultural performance is not commensurate with the efforts spent in formulating different agricultural development strategies, plans, and programmes in the country, in general, and in the hills and mountains, in particular. The total agricultural production has increased over time owing to the extension of marginal and sub-marginal land, including forests/pastureland. However, the crop yields have declined, particularly in the hills and mountains. Moreover, the production rate has not been able to keep pace with the population growth rate, resulting in decreased per capita foodgrain availability. The inaccessibility of the hills and mountains prevented the surplus foodgrains produced in the *terai* or the plains from being effectively diverted to the region. This situation compelled the planners and policy-makers to emphasise self-sufficiency of the hills and mountains in foodgrain production.

In this context, new improved agricultural technologies (e.g., HYVs that were successful in the plains) were introduced into the hills and mountains. A few exotic breeds were also introduced in order to develop the livestock subsector. However, they were not successful simply because the pre-conditions or required input materials were not available. HYVs are highly responsive to chemical fertilizers, irrigation, and agro-chemicals and these are not easily available in the hills and mountains because of inaccessibility. Farmers did/do not have enough cash to purchase them even if they are made available. Along with the deterioration of croplands, fodder and fuelwood are becoming more and more scarce. This is depicted by the fact that the size of livestock holdings per household is decreasing, although the total livestock population is on the increase. The use intensity of by-products as firewood is increasing. Thus the shortage of food and lack of employment opportunities are compelling people to migrate (seasonally/permanently) from the hills and mountains to the *terai*.

This situation implies that the sustainability of mountain agriculture is seriously threatened. Generally, it has been observed that the farmers' knowledge of mountain farming systems (crops, livestock, forestry, and their traditional resource management practices) is not recorded. An assessment of their knowledge and adaptation practices to mountain environments, conditioned by inaccessibility, fragility, marginality, and diversity may offer some clues. Upon their internalisation, some new openings may arise for revitalisation of sustainable mountain agriculture.

The objective and mandate of the International Centre for Integrated Mountain Development (ICIMOD) is to help promote the development of an economically and environmentally sound mountain ecosystem and to improve the living standards of the mountain populations of the Hindu Kush-Himalayan (HKH) Region, which includes Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan. Among the four thematic research and development programmes of ICIMOD, the Mountain Farming Systems' (MFS) Programme deals with the most complex problems of the HKH Region. Towards this end a large number of MFS assessment has been undertaken, including knowledge reviews, case studies, and field investigations. This document is the outcome of a case study on "Farmers' Strategies and Sustainability of Mountain Agriculture" conducted in the middle hills of Nepal.

Statement of the Problem

Visible consequences (in the form of landslides, soil erosion, desertification) alone are now drawing people's attention to the question of the fate of mountain people,* who in the past had not only matched their management skills to the surrounding environment to maintain their livelihood but had also managed to sustain the productivity of the resource base. Data recorded for over one or two decades also indicate that there is a sharp decline in the agricultural productivity of the hills and mountains of Nepal compared to that of the *terai*. There is also a declining trend in the outputs from other natural resource bases (e.g., forests, pastureland). This situation has a direct impact on the degraded quality of life not only up in the hills and mountains but down in the *terai* as well; per capita foodgrains and animal products, have decreased. Ironically, the performance of the agricultural sector** is worsening despite the fact that in terms of expenditure the total agricultural sector has increased by about 14 per cent per annum during the period 1970/71-1980/81. The yields of cereals (paddy, maize, wheat, barley, and millet) decreased by 0.46 per cent and the total production increased by less than 1.0 per cent, mainly because of the expansion in area under cereals by about 1.4 per cent per year during the same period. These are the disguised effects of unsuccessful development efforts of mountain agriculture.

In reality, invisible consequences (widening hunger gap period, increased severity of malnutrition, and other health hazards), although surfacing steadily, also indicate that all mountain areas have been exposed to serious threat on the basic premise of unsustainability. The carrying capacity of the *terai*, which until recently was the area welcoming all those immigrants from the hills and mountains, has also crossed its limit.

Thus the question now comes - what went wrong? Was degradation triggered by human activities or is something beyond it unclear and unanswered. One school of thought attributes the imbalance in the ecosystem mainly to human activities, whereas another school of thought points to the geo-morphological status of the mountains because the mountains are young and fragile. However, general consensus is that both factors are responsible for the degradation of the whole mountain ecosystem. Hence, the former can be controlled to a greater extent while the latter is beyond men's capacity. Therefore, there is an urgent need to understand the resource management practices adopted by the people in order to explore the means and ways to reverse the trend of environmental degradation. It has been speculated that the traditional resource management system, which included agricultural and other activities, was compatible to the surroundings. Therefore, a clear-cut cognisance of the management practices relating to land, water, vegetation, and their dependent activities is a must in order to formulate strategies to be adopted by both private (e.g., farmers) as well as public (e.g., government and corporate bodies) sectors so that mountain agriculture - the principal source of the livelihood of mountain inhabitants - can be developed on a sustainable basis.

It has also been observed that mountain characteristics (e.g., inaccessibility, fragility, marginality, diversity, 'niche', and human adaptation mechanism) are not taken into account during the formulation of periodical plans and programmes. If the attributes of activities (e.g., agriculture and other rural income generating activities) and the mountain characteristics do not tally, the potential benefits cannot be harnessed in a sustainable manner. Research studies to assess the means of checking further degradation should be carried out without further delay. The negative consequences otherwise will not only directly affect the quality of life of the mountain people, but will also have spillover effects in other ecological zones, for instance, in the *terai* area of the country.

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* In accordance with the ICIMOD mandate, the mountains and mountain people indicate both the hills and mountains and the people from both areas. This document adopts the same approach.

** The agricultural sector includes crops, livestock, forestry, land reform, and irrigation programmes.

Objectives of the Study

The primary objective of the study was to examine farmers' strategies and the sustainability issues of mountain agriculture. The main focus of the study was on the following specific issues.

(i) Examination of the importance of the crop, livestock, and forestry components while quantifying their linkages with reference to mountain farming systems.

(ii) Assessment of indigenous methods of resource management, both private as well as community-based resources, viz., forests, shrubland, grazing land, and pastures including arable land.

(iii) Documentation of traditional technologies practised by farmers in handling the mountain farming system

(iv) Identify the elements in farmers' strategies that helped them maintain the farming system viably and sustainably.

(v) Appraise the feasibility and viability of those elements in the context of recent changes, such as increased demographic pressure on land, changed market environment, and various institutional and technological changes associated with the development policies and programmes for the mountain region.

Purview of the Study

The investigation was a site-specific case study that concentrated on the identification of different components of the farming system and the quantification of their linkages. Documentation of the historical perspective of the farming system in relation to resource endownment (e.g., structure, status, etc), production flow, and their use and management was one of the principal components of the investigation. The study also examines and documents various responses that may be referred to as farmers' strategies to government practices, efforts, a changing environment emerging from demographic pressures, technological innovations, and other public policies and institutional interventions. Finally, the study focusses on the "sustainability" elements with a view to strengthening and incorporating them into public programmes for the sustainable development of mountain agriculture.

Methodological Approach

One of the principal aims of the study was to contribute towards the search for sustainable mountain agriculture. In this endeavour, the major elements behind the unsustainability of mountain agriculture were identified by studying and examining three different mountain farming systems; crop-dominated, horticultural crop-dominated, and livestock-dominated. Then various ways and means to strengthen/minimise the effectiveness of the sustainability/unsustainability of mountain farming systems were explored. The study was conducted in the middle hills of Nepal.

RESEARCH METHODOLOGY

The Conceptual Framework of Mountain Farming Systems

Resource endowments, their management, and extraction rates are probably the three most important variables of a sustainability matrix of any system. To some extent, abundance of one component may redress the frailness of the other variables, but excessive deterioration, even in one component, may cause irreparable damage to the whole system. At this stage, it may be difficult to clearly define the strengths and weaknesses of these three components of the matrix. However, it is assumed that heavy extraction rates (exceeding regenerative yield) and weak management are more problematic in the system and sensitive to the sustainability matrix. Extraction rates, in general, are influenced by the demand made by members of the system. Therefore, the demand function of goods and services will explain the nature and extent of the extraction rate.

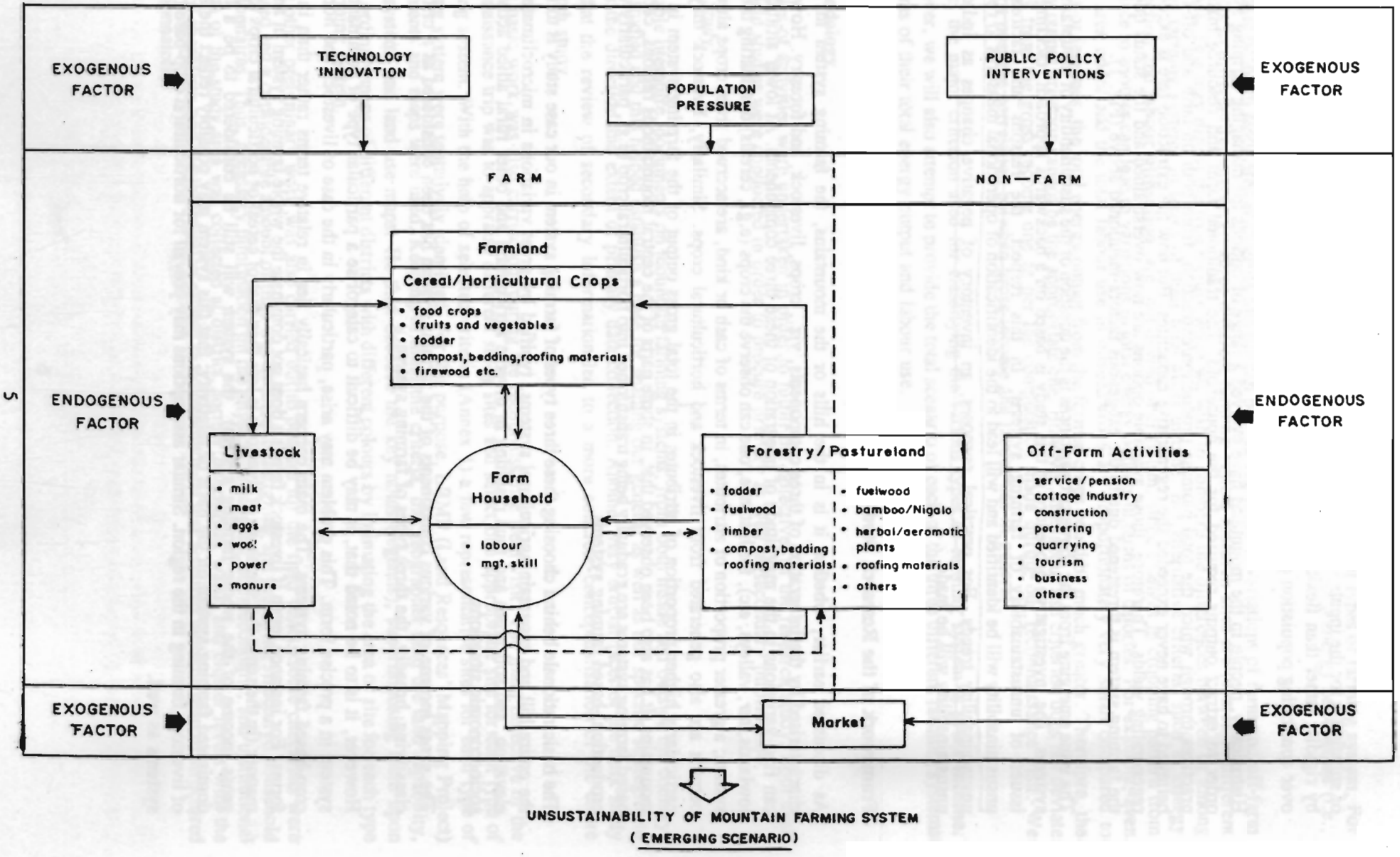
Traditionally, farmers in the mountains have been blending crop, livestock, and forestry components into one in order to satisfy their demands for various commodities. Considerable detailed sectoral analyses and well-documented reports on the Nepalese economy advocate that there is no other single sector that can absorb the upcoming labour force. This implies that the majority of people will have to be adjusted into agriculture for many years to come. This is more so in the mountain region where even the minimum level of industries and other manufacturing services has been constrained by the geo-physical settings. It becomes explicit that the mountain people do not have any other option but farming - which is also their 'niche'.

Figure 1 depicts that farmer-heads of households are the cynosure of the whole mountain farming system and that they manoeuvre the essential components: crops (farmland), livestock, and forestry. The realisation of the necessity for the integration of forestry by concerned people, including researchers, is, in fact, recent. These components are much interwound. However, the magnitude of attributes of each of these three components may differ as per the variation in altitude, microclimate, and other socioeconomic settings of a locality. For instance, if crop production has a greater role in the household economy in low altitude areas then livestock may be the major activity in high regions.

It has also been conceptualised that mountain farming systems are not only limited to farm activities but are also influenced by 'sideline' activities since supplemental farm inputs also come from the income accrued from the latter. As the conceptual model (Fig. 1) depicts these two farm and non-farm activities are within the control of farmers and thus the factors involved in both production systems are considered to be endogenous. Because the farmer has full authority over the three important variables of the sustainability matrix: accessible resource base, its management, and the extraction rate, he has command over factors of production, either in farm or non-farm activities. For instance, he may choose any activity, from construction work to quarrying and tourism, if these opportunities are available to him.

There are also certain factors that can heavily influence the whole farming system, but they are completely out of the farmer's control. Technology innovation, changes in demography, and public policy interventions are some examples. Let us take the case of hybrid maize which comes under technology intervention. In this case farmers have little option to manoeuvering the factors of production if they desire to obtain the expected output from the crop; they have to strictly follow a set of cultural practices which may be very difficult because of any number of reasons, viz., shortage of labour during a critical time period, lack of capital to purchase inputs, unavailability of inputs in time, and so on. Unavailability

FIG. I SCHEMATIC DIAGRAM OF CONCEPTUAL MODEL OF MOUNTAIN FARMING SYSTEM



of substitutes for the inputs is also a constraint in this respect. In such a situation farmers can be fortified by rigidity rather than flexibility through new technology interventions. Similarly, individual influence over controlling population pressure is trivial. The same is applicable in the case of market forces.

Historically, people in the mountains have evolved a range of options for managing farming systems in order to extract outputs required for the household. The traditional farm and resource management practices through which the total biomass production/extraction, from both on-farm and off-farm, are believed to have never exceeded the regenerative capacities. But now the extraction rate is exceeding the regenerating yields. Therefore, those available options are now overstrained and the status quo ante of the farming system is threatened due to the exogenous factors mentioned above (Fig. 1).

The issue emerging from the above circumstances is the question of the sustainability of mountain farming systems. The investigative procedure of this study is based on a backwards approach; tackling first the issues of unsustainability of farming systems. In this respect, the reasons and factors behind unsustainability will be identified and will lead to the identification of operational measures to reverse the unsustainability trends. For practical purposes, an inventory of negative changes as indicators of unsustainability will be made.

Framework of the Research Study

As discussed earlier, whether it is in the hills or the mountains, the farming system in Nepal is characterised by the integration of three components, viz., crops, livestock, and forestry. However one can find variations in the magnitude of integration of these three components. At lower altitudes (e.g., lowlands, *tar*, valleys, etc), for instance, one can observe the crops (e.g., cereals) dominating the farming system; a greater proportion of attributes, in terms of cash or kind, are accrued from crops although the outputs are also generated from livestock and horticultural crops. Similarly, livestock may have a particularly higher proportion of attributes in the total gross output of the farming system in the high mountains. It has also been observed that, in some parts of the central mountainous regions, cereal crop-based farming systems are gradually being transformed into horticultural crop (e.g., particularly vegetable production)-based farming systems.

The basic rationale behind choosing these three types of farming system in our case study is to represent the entire hill and mountain agricultural systems, typified by great variations in microclimates, slope, elevation, and soil types and thus resulting in diverse agricultural and other rural allied activities and socioeconomic situations.

The **gross income** of various components of the farming system has been considered as a criterion for classifying, broadly, the three types of farming system.

However, it is to be noted that, it may be difficult to categorise a particular type of dominant farming system in a precise form. This problem may arise, particularly in the case of livestock and horticultural crop-based farming systems. The main concern basically lies in relative terms rather than in absolute forms. For instance, even if livestock farming does not dominate the whole farming system in an absolute manner (in the sense that the share of livestock is less than that of cereal or horticultural crops to the total gross income of the whole farming system) the system will still be considered to be a livestock-dominated farming system on the basis of relativity; that this system may possibly reflect the best form of livestock farming in the region. Similar assumptions may prevail for horticultural crop-based farming systems as well.

No one can deny that there could be other criteria in categorising different types of farming system. For instance, outputs generated by each component, measured in terms of their total **energy production** (i.e., calories) and **labour use** (in terms of mandays).

The basic problem associated with gross income can be referred to price variations of farm and off-farm products in different regions (e.g., three different farming system research sites are located in different regions). This may distort the true picture when we wish to compare the differences between or among various farming systems in terms of their total gross income. But alternative criteria, such as **energy production** and **labour utilisation**, are not devoid of criticism, since changes in cropping pattern from one place to another can lead to variations in total energy outputs in terms of calories. For example, even if the area under and the total labour use in oilseed crops are proportionately very small compared to cereals or legumes, the total energy output from the former crops could be much greater. Therefore, the energy output criterion cannot be the appropriate one. However, the labour use criterion does not deviate greatly from the gross income one as per the computation made during our reconnaissance visit. We found a positive correlation between gross income and labour use in general.

Hence, the major criterion used for classifying the various types of farming system is **gross income**. However, we will also attempt to provide the total scenario of each of the three different farming systems in terms of their total energy output and labour use.

Methodology

A series of activities were undertaken in order to fulfill the objectives of the research study. Both desk and field studies were conducted in order to procure primary as well as secondary information.

Desk Study

Available literature, documents on mountain farming systems, from both inside and outside the country, were studied and this helped establish a base for shaping our general as well as our specific strategies to assess the direction and extent of primary data collection. Another very crucial facet of the desk study was that the review of secondary information led to a more concrete conceptualisation of the entire research study.

Some basic work was also carried out during the reconnaissance field visit. The main objective of the reconnaissance trip was to appraise different study sites and select one appropriate site for each type of farming system. With the help of selected criteria (Annex 1) a few representative sites for each type of farming system were tentatively identified. For this purpose, LRMP (Land Resources' Mapping Project) documents and maps were used. Keeping in mind the criteria, the geographer read the land capability, land system, and land use maps. He then decoded the key notes (legends), superimposing them upon other ordinary maps of different districts with different colours by intimating the area or site for each type of farming system.

Some other preliminary work was also carried out to prepare for the field visits. Some checklists were prepared and a considerable amount of time was devoted to designing and preparing structured household questionnaires. Thus, necessary information on the physical, biological, socioeconomic, and institutional aspects of the study area was collected at district, former *panchayat*, ward, and cluster levels with the help of checklists, and the information related to household level was acquired with the help of structured questionnaires.

Survey Procedure

Two kinds of surveys were carried out during the field visits.

Reconnaissance Field Visit. The research study sites/locations - Kavre, Sindhupalchowk, and Dolakha districts of the Central Development Region - were visited during the reconnaissance survey visit with the principal aim of confirming and assessing the conditions and situations of those sites in order to select the most appropriate (representative) sites for detailed study.

During the course of the reconnaissance, each district headquarters was visited and discussions held with the concerned government/non-government authorities (e.g., agriculture, livestock, forestry). The discussions included assessments of identified sites in line with the prevalence of selected criteria. The visits also included the exploration of other suitable areas for undertaking different farming research studies. Subsequent visits were made for further confirmation of decisions, once ratified by earlier discussions. During this time period, more sites than identified during desk study were visited. Further computations and assessments were made with regard to selecting the appropriate site once the study team, comprising of one agricultural economist, one agriculturalist, and one or two research assistants, returned to the centre after spending three weeks in the field.

Data and information on each of these various Village Development Committees (VDCs) (former *panchayats*) and specific sites were tabulated and computed. As per the study site selection criteria, the sites were rated according to the merits and demerits. For example, whether a particular site was within the range of elevation, slope, aspects, accessibility/inaccessibility, and cropping patterns that were being looked for in the context of a particular type of farming system for detailed survey had to be determined. In this context, all the visited sites were rated according to a rough score as per the prevailing conditions of the sites against our desired level. Lastly, one specific site was selected for each of the three different farming systems (Table 2.1) on the basis of highest merit.

Table 2.1: Locations of Research Study Sites

Types of Farming Systems	Locations of Study Sites		
	Specific Site (Village)	Village Development Committee	District
1. Crop-dominated	Ekle Gaon	Dhuskun	Sindhupalchowk
2. Horticultural Crop-dominated	Bhadure	Naubise	Dhading
3. Livestock-dominated	Yelung	Shyama	Dolakha

Pretesting of structural household questionnaires was also carried out during this preliminary field visit, and the questionnaire redesigned to make it compact and concise while incorporating all necessary enquiries related to household activities.

Detailed Field Visit. After completion of the necessary background work, a detailed field visit was conducted to acquire primary information. The general investigation procedure adopted was the same for all research sites. However, some specific criteria and activities were also considered and taken into consideration, owing to variations in the nature of the farming system. These are briefly discussed in the following sections.

A. Cereal Crop - dominated Farming System

Selection of Study Site

The study site - Ekle *Gaon*" under Dhuskun VDC in Sindhupalchowk District - was finally selected for detailed study as a cereal crop-dominated farming system after a rigorous selection procedure. The Ekle *Gaon* study site consists of Ekle *Gaon* along with other two adjoining villages, i.e., Ekle *Salle* and Ekle *Birta*. The total number of households in the site or cluster is estimated to be 140.

Selection of Households for Survey

A list of households falling into the Ekle *Gaon* cluster was prepared, indicating the name of the chief of each household along with the size of owned landholding and operated landholding. Then the households were classified into five categories, viz., large, medium, small, marginal, and landless as per the criteria developed by the National Planning Commission (1977) A total of 30 households were then selected, employing a stratified random sampling method. The ethnicity issue was also considered in selecting the sample households. Tables 2.2 and 2.3 show the total number of households considered in the Ekle *Gaon* cluster and the total sample size by farm size and ethnicity respectively.

Table 2.2: Total Number of Households, Their Proportion and Sample Size By Farm Size in Ekle *Gaon* Study Site (Dhuskun)

Farm Size[1]	Total Households		Sample Size Household
	No.	%	No.
Large	18	13	4
Medium	43	31	9
Small	56	40	12
Marginal	17	12	4
Landless	6	4	1
Total	140	100	30

Source : Household Survey, APROSC 1989.

[1] Farm Category — Operated Landholding Size (*ropani* [1.0 ha = 19.8 *ropani*])

Large	-	abobe 20.0
Medium	-	10.0 to < 20.0
Small	-	4.0 to < 10.0
Marginal	-	less than 4.0

A farmer who owns less than one *ropani* of operated land, excluding the area covered by house kitchen garden, is assumed to a landless farmer.

Table 2.3: Total Number of Households and Their Proportions By Farm Size and Ethnic Group in Ekle *Gaon* Study Site (Dhuskun)

	Farm Size											
Ethnic group	Large		Medium		Small		Marginal		Landless		Total	
	No	%	No	%	No	%	No	%	No	%	No	%
Brahmin	-	-	-	-	8	12	-	-	-	-	8	6
Chhetri	12	70	20	7	14	27	4	20	-	-	50	36
Newar	4	20	2	4	-	-	-	-	-	-	6	4
Thami	2	10	20	7	26	47	8	50	-	-	56	40
Kami	-	-	-	-	4	7	5	30	5	100	14	10
Bhujel	-	-	1	2	5	7	-	-	-	-	6	4
	18	100	43	100	57	100	17	100	5	100	140	100

Source : Household Survey, APROSC 1989.

Data Acquisition

(a) Household Level Information. Heads of sample households, irrespective of sex, were interviewed with the help of a structured questionnaire. Single to multiple visits to a sample household were made in order to collect information with the best possible precision. The recall method was the principal means of data recording. The questionnaire was exclusively designed to acquire all necessary technical and socioeconomic implications/settings of various farms and 'sideline' activities performed by various household categories and ethnic groups. Generally, household level data/information were recorded for one complete year. However, some attempts were also made to acquire time series data on, for instance, fuelwood, fodder, and water-fetching time; number of crops grown per year; differences (e.g., increased/decreased) in agricultural inputs used; changes in stall-feeding practices; and household expenditure. The time series data included the situation of production, consumption, and management practices of five years, 10 years, and before 20 years.

(b) Cluster Level Information. The study site - Ekle *Gaon*, was considered to be a cluster of households. Some key informants and local leaders were contacted and interviewed with the help of checklists in order to document all necessary information which includes from demography to agriculture and from water resources and forestry to environmental aspects of the cluster. Special importance has been attached to this cluster level information since it has, to the best possible extent attempted to capture a historical perspective of all aspects, directly or indirectly related to the resource base, resource management practices, and their implications on the environment of the whole cluster area. Information about the situation of the cluster area five years, 10 years, and 20 years ago, for example, in the case of population density, people's migration patterns (seasonal/ permanent), family size, and resource base holding size per household (e.g., cultivated land, grazing/pasture land, forest, livestock holding, etc) in addition to information on agricultural inputs and outputs (e.g., seed, fertilizer, FYM, crop yields, etc) were also acquired. A series of enquiries on the indicators of unsustainability of mountain agriculture, which form a very important part of the whole research study, were carefully made. The indicators include - frequency of landslides, soil erosion, flooding and the extent of damage, hunger gap period, and the extraction rate of natural resources (e.g., fodder, fuelwood, water,) and the time taken collecting them. Historical background information regarding changes in crop-cultivation practices, cropping patterns, cropping intensity, and the rationale behind shifting to new types and varieties of crops and animal husbandry practices were collected. The cluster level enquiries also attempted to gather information on the implications of public interventions and rural institutional arrangements as well as changes in the overall quality of life between then and now.

These enquiries were addressed primarily to elderly and informative persons in the villages who could provide historical background information covering a period of 30 years or more.

(c) Ward Level Information. Ward level information on population, land use, agriculture, and the livestock situation, including resource management practices, were collected with the help of checklists. This information was collected as background information of the cluster area.

(d) Village Development Committee (former *Panchayat*) Level Information. Similar information including other socioeconomic and institutional aspects, of Naubise *Panchayat* (former) were collected. Where and whenever possible, time series data on the use of agricultural input use (e.g., seeds, fertilizers, etc) and institutional credit were also acquired from AIC and ADB/N. The acquisition of this level of information also included the existing physical and institutional infrastructure.

(e) District Level Information. District level information on land use, agriculture and its allied activities, population, and other socioeconomic settings were gathered from the concerned government and non-government offices located at the district headquarters.

B. Horticultural Crop-dominated Farming System

The study was carried out in Bhadaure Village area of Naubise *Panchayat* (former) of Dhading District (Table 2.1).

Selection of Study Site

Based on the discussions held with local leaders, key informants, and the information provided by the agricultural sub-centre located at Naubise Bazaar, a profile on fruit and vegetable cultivation in Naubise *Panchayat* (former) was prepared by estimating the number of growers and the area under various horticultural crops by ward and also by village within the wards. The total number of households in the site or cluster is estimated to be 90.

Selection of Households for Survey

Again, a brief profile of the Bhadaure Site was formulated by mentioning heads of household and the size of the total landholdings, including the area under vegetable production. A total of 30 households was then selected for interview by employing a stratified random sampling method* which is not only representative by farm size but also by ethnicity - factors which play a substantive role in the adopting a particular type of occupation or farm activity. Tables 2.4 and 2.5 depict the number of vegetable growers and non-growers and the sample size by farm size and also by ethnicity.

Data Acquisition

The data acquisition procedure for this farming system is similar to that employed in the cereal crop-dominated farming system. Necessary data/information were compiled and documented, similarly, through the district, *panchayat* (former), ward, cluster, and household levels. Input and output coefficients of agricultural resource base/management and other allied activities for one complete year were compiled and computed through multiple visits to the households.

C. Livestock-dominated Farming System

For the livestock-dominated farming system several similar steps were employed to acquire necessary information.

Selection of Study Site

Once the Shyama *Panchayat* (former) of Dolakha District was selected, comprehensive discussions, held particularly with the *Pradhan Panch*, district vice-president, and other key informants were held on the overall settings (including agriculture, livestock, and forestry conditions) of the *panchayat* by ward and in some cases even by village. In addition, a rapid rural appraisal was also made by employing concise, structured two or three page questionnaires relating to the socioeconomic setting of the community. This

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* First of all a list of vegetables and non-growers was prepared. This first stratum was then classified into various farm categories: large, medium, marginal, and landless, based on landholding size. Farmers were also categorised by ethnicity.

Table 2.4: Vegetable Growers and Non-growers and Sample Size By Farm Size in Bhadaure Study Site (Naubise)

Farm Category	Vegetable				Sample Size			
	Growers		Non-growers		Growers	Non-growers	Total	Proportion
	Household No	Proportion (5%)	Household No	Proportion (5%)	Household No	Household No	Household No	%
Marginal Farmer	-	-	-	-	-	-	-	-
Small Farmer	20	26	9	75	7	3	10	33.4
Medium Farmer	23	29	-	-	7	-	7	23.3
Large Farmer	35	45	3	25	12	1	13	43.3
	78	100	12	100	26(87)	4(13)	30	100.0

Source : Household Survey, APROSC 1989.

Note : Figures in parentheses are in percentages.

Table 2.5: Number of Households and Sample Size By Ethnicity in Bhadaure Study Site (Naubise)

Ethnicity	Households Production		
	No.	%	No
Brahmin	68	75	22
Chettri	6	7	2
Newar	3	3	1
Bhujel	3	3	1
Tamang	4	5	2
Kami/Sunar	6	7	2
Total	90	100	30

Source : Household Survey, APROSC 1989.

process facilitated the satisfactory selection of the "**Yelung**" site of Shyama *Panchayat* (former) Yelung includes some adjoining villages named Sharba Khasha, Bagdung, and Chyane from ward number 5 and Gepung, Changam, Gyamnel, Parma, and Lhacha from ward number 6. The total number of households in the site or cluster is estimated at 130.

Selection of Households for Survey

With the help of the present as well as the former ward chairman, local leaders and key informants, a small profile was prepared by enlisting heads of households, their landholding sizes (own and operated) by type of land, and the size of livestock holding by type of animal. Firstly, landholding sizes were converted into standard units - *ropani* - from the local unit indicated by seed rate. Similarly, all kinds of livestock were converted into a single but standard unit - Livestock Unit (LSU). Based on stratified random sampling a total of 30 households was finally selected, keeping in mind three representative criteria: farm size, livestock holding size, and ethnicity (Table 2.6).

Data Acquisition

The data aquisition procedure employed for this farming system was also the same as for the previous two.

Analytical Procedure

Simple tools were used to analyse the data. In the absence of time series data, cross-sectional data have been used for cross-tabular analysis.

Limitations of the Study

The absence of baseline/benchmark studies was recognised realised as a severe handicap, particularly in comparing the present situation of the mountain farming systems with the past three or four decades and in drawing the sustainability implications of farmers' strategies in response to mountain charactersitics and public

interventions made by the Government. At this juncture, historical background information compiled through the memory recall method was solicited. Another major problem of this present study has been the premise of non-sampling error, and it was particularly so in the case of the livestock-dominated farming system study site where farmers were not conversant in the Nepali language, although one or two key informants (adequately educated) were hired to help the study team members throughout the study period at the site. However, the best possible efforts have been made to overcome these problems by having extensive and comprehensive discussions with farmers, local leaders, and key informants, particularly with those who could recall the past situation of farming and resource management systems adopted both during normal and abnormal as well as odd periods (e.g., drought, hailstorm, flooding, insect and disease infections, and other natural calamities - landslides).

Table 2.6: Total Number of Households and Sample Households by Farm Size in Yelung Study Site

Farm Size	Total No. of Households (No.)	Proportion of Households (%)	Sample Households (No.)
Marginal	61	47	14
Small	60	46	14
Medium	9	7	2
Large	-	--	
Total	130	100	30

Source : Household Survey, APROSC 1989.

3

COUNTRY BACKGROUND

General

Nepal is a small land-locked Himalayan Kingdom sandwiched between the giant nations of China and India, and has a physical area of 147,181 square kilometres. It is situated between 80°15' - 88°10' E longitude and 26°20' - 30°10' N latitude. Its length is about 880 kilometres from east to west and its width, varies from 130 to 240 kilometres from north to south. It is rectangular in shape - more precisely the shape of a broken brick. Although covering a small area, but wide variations in microclimate and topography make it unique. Nepal boasts the presence of the highest mountain (Mt. Everest) and one of the deepest gorges (Kali Gandaki) in the world. The climate is characteristically from subtropical to alpine. The average annual rainfall is about 1,600 mm with 80 per cent of it occurring during the monsoon, from June to September.

The country can be broadly divided into three parellel geographic regions extending from east to west - the *terai*, the hills and the mountains. The *terai* belt or the plains (60-300 m), which lies in the southern part of the country, extends almost throughout the length of the country and covers approximately 23 per cent of its total area. It is this region that produces the bulk of the country's foodgrains. The hills (300m to 3,000m) from the broadest strip among the three belts, run along the central part of the country, and cover about 42 per cent of the total land area. This belt consists of high ridges and steep slopes, including the Mahabharat Range, and is interspersed with many valleys, including the Kathmandu Valley. The northernmost strip, along an altitude of roughly 3,000 metres and above, is known as the mountains and covers about 35 per cent of the total area.

The population of Nepal, estimated as of 1991, is 18.1 million, with a population density of 123 persons per square kilometre of total land area and 586 persons per square kilometre of cultivated land. The population growth rate, which was 1.8 per cent/annum between 1952/54-1961, increased to 2.07 per cent during 1961-71 and to 2.66 per cent during 1971-81 and to 2.08 per cent in 1981-1991. According to the 1981 census, the economically active population is estimated at 46 per cent of the total population and the farming households constitute about 82 per cent of the total households.

The economy of Nepal is dependent mainly upon agricultural production. However not only is the land available for agriculture severely limited by topography, but the agricultural productivity has also declined over time because of improper land use practices owing to mounting population pressure. Water, another abundant natural resource, is grossly undertapped both for agricultural and industrial purposes, mainly due to the lack of adequate investment and marketing problems. Despite the huge potentials of other sectors such as industry, mining, and tourism, their contribution to the economy has been minimal because of the lack of financial and human resources and necessary infrastructure.

Thus, agriculture has remained the leading sector of the economy - employing over 90 per cent of the total population, contributing 60 per cent of the GDP, and occupying up to 80 per cent of the share in exports. Agro-based industries, mainly engaged in cereal processing and edible oil extraction, account for more than 75 per cent of all industrial establishments. The agricultural sector not only dominates the economy but also has a pervading impact on the other sectors in its role as the supplier of raw materials and the consumer of various inputs and services.

The Nepalese economy is undergoing slow economic growth, despite planned economic development efforts over the last three decades. The per capita GDP, at about US$ 180, is one of the lowest in the world.

National Strategies and Policies for Agricultural Development

Development Plan Objectives, Policies, and Resource Allocations

Agriculture has been accorded high priority, particularly from the Fourth Plan period (1970-75) onwards, although the importance of the sector had been appreciated since the first formulation of systematic plans in 1956. The First Plan emphasised the increase of agricultural production through supply of modern inputs and dissemination of production technologies through establishment of rural cooperatives. In the Second Plan, the concept of specialisation in livestock, horticulture, and food crops, according to the geographical regions of the country, was introduced although the concept was never translated into actual projects during this or any other subsequent plans. The Second Plan also emphasised the establishment of research centres, the need to disseminate the findings of research, the need for monitoring and evaluating various programmes, and systematic collection of data pertaining to agriculture. However, it was only in the Third Plan that output targets were fixed. In earlier years, the major focus of the Government's development activities, particularly in agriculture, was the *terai*.

However, recognising the needs of different regions as well as the ecological differences, the Fourth Plan introduced the strategy of "corridor development" designed: (i) to minimise disparities in progress in different regions; (ii) to optimise the comparative advantages of the different regions - surplus manpower and potential for production of livestock and horticultural crops in the mountains and hills and surplus foodgrains, supplies of consumer goods, and access to Indian markets in the case of the *terai*; and (iii) to integrate the economies of the mountains, hills, and the *terai*.

The Fifth Plan treated agriculture as the lead sector of the economy; revived the concept of specialisation according to geographical regions, i.e., livestock in the mountains, horticulture in the hills, and foodgrains and cash crops in the *terai*; and expanded the concept of "corridor development" by designating four development regions, each with a development centre in order to establish a north-south growth corridor. Recognising the limitations imposed by transport difficulties as well as by resource endowments and existing production patterns, the Sixth Plan emphasised limited specialisation and increased food production in suitable areas in the hills to meet their own requirements. In addition, the problems of environmental deterioration and ecology were given special attention. The objectives of the Seventh Plan, which are similar to those of the Sixth Plan, are to: (i) increase production at higher rates; (ii) increase productive employment opportunities; and (iii) fulfill the minimum basic needs of the people. The plan accords overall priority to the development of the agricultural sector and emphasises the development of forest and water resources and soil conservation.

All plans have argued in favour of top priority to the agricultural sector. However, the lion's share (between 30 to 40%) of the development expenditure was absorbed by the transport and power sectors up to the Fourth Plan because Nepal lacked the basic transportation and communications' infrastructure essential for rapid overall development of the country. With the gradual development of a nucleus transport and communications' network, resource allocation to the agricultural sector also increased slowly. Since the Fifth Plan, agriculture has been treated as the lead sector of the economy and accorded topmost priority. The share of agriculture in the total development expenditure increased from 13.6 per cent in the Second Plan to about 30 per cent in the Sixth Plan. The Seventh Plan allocated 34.3 per cent of the total development expenditure for the development of the agricultural sector.

Crop Development Strategies and Policies

The First Plan emphasised increased crop production through the supply of modern inputs and dissemination of production technologies. The Second Plan emphasised the need for establishing research centres, disseminating the findings of research, monitoring and evaluating various programmes as well as the systematic collection of data. During the Third Plan, production of food and cash crops was emphasised by setting production targets. The Fourth and Fifth Plans emphasised crop production on a regional basis and this pushed cereals and cash crops into the *terai*. The Sixth Plan, recognising the problem of food shortage in the hills and mountains, emphasised the need for increased food production in the region and adopted a policy of carrying out intensive agricultural development activities in the river basin areas of the hills and mountains. The Seventh Plan (1985-90) envisaged making the hills self-sufficient in foodgrains in the following 10 years by executing a foodgrain production programme as a campaign. The plan also stressed problem-oriented adaptive research with an emphasis on rainfed farming. All the plans and policies regarding crop development have laid maximum emphasis on the increased use of improved seeds and chemical fertilizers and the optimum use of irrigated areas.

Despite the strong emphasis on the crop development sub-sector of agriculture, the performance was not encouraging. The total crop production increased due to an increased area under cultivation, but the crop yields are declining year after year. This is mainly because of the lack of understanding of the hill and mountain situations. The HYVs, which were successful in the *terai*, were introduced in the mountains. Because of such agricultural policies, crop yields did not improve. The reason is that the prerequisites for HYVs (e.g., improved seeds, chemical fertilizers, agro-chemicals, and irrigation) were not easily available in the region because of the inaccessibility, and marginality characteristics of the mountains. Only a few years back, this reality was recognised and one separate chapter entitled "Hill and Mountain Agriculture" was added to the agricultural component of the nation's periodic five year plans. However, in the absence of operational plans and programmes, this strategy and policy has not been able to bring about substantial improvement. The country's impetus in order to make the hills and mountains self-sufficient in food production may not be viable from the sustainability point of view, although technically it is feasible. Therefore, the crop development policy and strategy should be emerged with a fuller understanding of the hills and mountains. The local resource-centred production pattern, in general, could be the appropriate strategy since it will encourage the adoption of those agricultural technologies that thrive on local input materials. This strategy will flourish in remote areas whereas improved technologies may also do well in accessible areas where obtaining the necessary input materials are not problematic.

Horticultural Development Strategies and Policies

His Majesty's Government of Nepal (HMG/N) has emphasised that horticultural development be given higher priority in the hills. In order to increase horticultural production to meet the increasing demand for fruits and vegetables, particularly in the urban areas, HMG/N has adopted fruit and vegetable production programmes concentrating in areas along road networks, in urban areas, and in densely populated areas. In order to intensify horticultural production, emphasis has been given to designing production programmes in such a way that the agencies concerned should act jointly in the production pockets to help the growers.

Emphasis has been laid on carrying out research on horticultural crops to develop production technologies in conformity with the problems faced by the farmers in growing horticultural crops. However, because of the lack of necessary support in terms of resources and manpower allocation, research activities in this sub-sector have been minimal and this, in fact, has hindered the effectiveness of horticultural development programmes.

Besides these technical bottlenecks, one of the biggest problems the horticultural sub-sector is facing is the lack of market integration. Large areas have been brought under apple farming in Jumla and Mustang, but the farmers are facing acute marketing problems because the markets are far away from the production areas. Nepalgunj, Pokhara, and Kathmandu are the major markets but because they are accessible only by aeroplanes it becomes very expensive for consumers to buy the airlifted fruits. Despite the ample production of fruits, farmers are not accruing any benefits. Rather, they are frustrated and farmers in Helambu, which is not that very far from the Kathmandu Valley but which is inaccessible, have even started to uproot the apple trees and use them as firewood. In the absence of effective operational plans and programmes, farmers will not be able to harness hill and mountain 'niche'. Rather they will go on to cultivate foodcrops which will not contribute to sustainable production in mountain agriculture.

Livestock Development Strategies and Policies

Livestock development policies in the past have generally been weakly spelled out. The general policies that have been adopted in the past realise the need for increasing livestock production without increasing the livestock population. The fourth and fifth plans emphasised the policy of concentrating livestock development in the high hills and mountains and stressed the need for expanding extension and other related services through the development of middle level technicians.

With a view to benefitting farmers, the policy adopted in the Fifth Plan focussed on the role of the private sector in marketing livestock products and producing livestock inputs such as breeding materials, grass seeds, fodder saplings, and concentrated feeds. The Sixth Plan has emphasised the need for concentrated efforts on problem-oriented, applied types of research, including studies on local resources such as native breeds of livestock, local species of grasses and their use and proper use of agricultural by-products or crop residues as animal feeds. The Seventh Plan aimed to attain self-reliance in livestock products through increased production and emphasised that livestock development programmes be concentrated along road networks, urban areas, and densely populated areas and that the pasture problems of the northern areas be solved. The plan also stresses increased production and distribution of livestock inputs and effective livestock extension and animal health services.

In the past, all sectoral and sub-sectoral development strategies were formulated in isolation. Integrated crop-livestock-forestry farming practice is basically a traditional one. However, emphasis on this is quite recent; particularly the integration of forestry with farming systems was recognised fully only a decade ago. The agricultural development strategies and policies were not designed in an integrated manner. Livestock were not really considered in designing crop development programmes and vice-versa. In this context it is not surprising to note that the forestry sector never thought of livestock while designing their development strategies.

Hence, the livestock population increased also, as a result of improved animal health services while the animal feed supply situation remained the same, which consequently accelerated the overgrazing/degrading of the forest/pasture resources. Therefore, livestock productivity, despite some improvements in genetic materials, has not really improved. The livestock credit policy has encouraged farmers to acquire animals but without making assessments of farmers' carrying capacities and without encouraging an increase in the feed resource base.

Finally, the livestock farming 'niche' of the high hills and mountains can only be harnessed when appropriate development strategies and policies are formulated and implemented. In this context, not only the crops but also forest development strategies must be guided by livestock considerations and vice-versa. Livestock pricing policies, so far formulated and implemented, are yet to prove meaningful.

Government milk prices are always below market prices and this has not encouraged farmers to produce milk. The increase in the price index of livestock products is always much lower than that of agricultural commodities.

Forest Development Policies

The Forest Nationalisation Act of 1957 brought all forest lands under government control. The pattern of forest resource use before the act, particularly in the hills, was based on a system of harvests regulated by the villagers which enabled prime species to regenerate after an initial harvest. Nevertheless, because of the increasing population pressure on forest lands, the act was promulgated with a view to preserving an important source of national wealth and providing for protection and controlled exploitation by the people. Unfortunately, the act was misunderstood by the people who believed the Government had removed their right to free access to and use of the forests. Under these conditions, villagers rapidly ceased to employ any traditional rules for forest management and thus forest management at community level just disappeared. Fuelwood, timber, and fodder were collected indiscriminately and the rate of forest destruction was significantly accelerated.

In recognition of the need to involve local communities in protection and regeneration of forests, the 1957 Act was amended in 1977. The amendment called for the designation of the *Panchayat* (former) Forest (PF), *Panchayat* (former) Protected Forests (PPF), religious forests, and contract forests in order to encourage private planting and community sanctions against destructive practices.

The current policy is to promote community forest development, operating within policy guidelines that provide for greater community responsibility towards forest management and protection. Both the sixth and the seventh plans emphasised the policy of increasing people's participation in management and protection of forest resources. Development of community forests has been given high priority. However, due to lack of effective operational plans and programmes, the policies have not had much impact on forest conservation and protection. Still, the people fear that once the (former) PF, PPF, and community forests (CF) are revitalised through afforestation/reforestation with the help of people's participation, the Government may have control over the forests. In fact the Government has also made a provision for lease forests, but the people have not dared to come forward and develop the forests as private forests on lease. Another issue is that unless they are assured of having adequate fodder for their animals from the reforestation and afforestation programmes, people will not be ready to participate wholeheartedly in the Government's forest development programmes (e.g., PF, PPF, CF, etc).

Until recently, timber and fuelwood production was the prime target of the forest development strategy, while ignoring and undermining the fact that the forest is the major source of animal feed. Finally, unless the conservation and utilisation rights of forest/pastureland and their products is fully assured for local communities, forest development will not take place in a sustainable manner.

Mountain Farming Systems

General Features of the Hills and Mountains

The hills and mountains lie in the northern part of the country and cover a total area of 113,390 sq. km. of which 9.8 per cent is cultivated land, 41 per cent forest, 14.8 per cent grazing land, 19 per cent snow covered, and the remaining 14.5 per cent rock out-crop and water bodies. The population (1985) in the region is about 9.2 million with a population density of 81 persons per sq. km. of the total land and 827 persons per sq. km. of culitivated land.

The topography is variable with slopes of up to 80°. Farming is being practised on slopes up to 30°. The hills are intersected from north to south by about 6,000 rivers. The deep river gorges have a major influence on the agriculture in the region; in limiting transport and communications; and in creating numerous microclimates that are conditioned by elevation, direction, and steepness of the slopes.

The climate in the hills and mountains is controlled by the monsoon winds, elevation, slope, and aspect. The climate is extremely diverse, being subtropical in the lower hills and river basins to alpine in the higher mountains. The rainfall is highly seasonal with about 80-90 per cent of the total amount falling during the four monsoon months (June-September), followed by eight months of negative water balance with scanty rainfall. Average annual rainfall varies from around 2,500 mm in the eastern and central hills to less than 1,000 mm in the western hills. On the northern side of the Himalayas, there are some high altitude valleys that lie in the rain shadow and have an arid to semi-arid cold climate. Temperature varies with altitude and, therefore, decreases from south to north. Mean monthly temperature ranges from about 2.5°C in summer (May-June) to below freezing in winter (December-February), depending upon elevation, slope, and aspect. Freezing temperatures are rare in the area with up to 1,300 m elevation on south-facing slopes, but they do occur from November to February on north-facing slopes and at higher altitudes. The permanent snowline starts at 4,800 m, below which snowfall is seasonal.

Hailstorms in the hills occur in two spells: first during March-May and second during October-November. Snowfall and frost are major constraints for winter crops at higher altitudes. In general, soils in the hills and mountains are medium to light-textured and dominated by of coarse sand and gravel and have low to moderate water holding capacities. However, in river valleys, fine sand and silt are commonly found. Soil reactions are moderately acidic and the organic matter, nitrogen, phosphorus, and potash contents vary from low to moderate. Soils on steep slopes are usually eroded, stony, and poor for agriculture. Poorly managed, marginally cultivated, and degraded forest and grazing lands are prone to very high rates of soil erosion. Most parts of the hills and mountains are inaccessible by motorable roads, limiting the smooth flow of goods and services required for the development of agriculture.

Small and subsistence farmers are predominant in the hills and mountains. Most farmers farm less than 0.5 ha and it is not uncommon for a single holding to be divided into seven or eight parts. The family size ranges from six to eight persons. The average farm size is too small to generate marketable surpluses.

The Farming System

The limited transport and communication infrastructure, unavailability of reliable markets and production inputs, and high variations in microclimates, accompanied by large family sizes on small fragmented farms on hill terraces and steep slopes, have led the farmers in the hills and mountains to adopt the subsistence-oriented mixed farming systems which are characterised by substantial diversity and also a high degree of self-reliance. The system uses a great variety of crops, including perennial fruit and fodder trees and livestock on farmland, and depends to a large extent on available forest and rangelands which supply fuelwood, fodder, compost, timber, poles, and other products to the system. Thus, crop production, animal husbandry, and forestry constitute the three main, closely and inseparably integrated, components of the mountain farming system.

Crop Production

Crop production in the hills and mountains is practiced on valley bottom land, small plateaux along the river banks, and on terraced slopes of which about 80 per cent or more consist of rainfed upland terraces, and 20 per cent of less irrigated lowlands. Main crops in the region are maize, rice, and wheat. In 1987/88, these crops were grown on 37, 25, and 19 per cent of the total cropped area. Other widely

grown crops are millet (10%), potatoes (4%), barley (2%), and oilseeds (2%). Legumes occupy relatively small areas in the region and some of the more common ones are soyabean, groundnuts, blackgram, and horsegram.

Cropping patterns in the region are usually maize-based on rainfed uplands and rice-based on irrigated lowlands, although potato-based patterns may be common at higher altitudes. The predominant cropping patterns on uplands are maize, relayed with millet and maize, followed by oilseed, potatoes, barley, or fallow. In the lowland areas, rice is usually followed by wheat and sometimes by barley, potatoes, or fallow. At higher altitudes, potatoes are usually grown as monocrops and are sometimes followed by buckwheat.

Traditional farming practices predominate in the hills and mountains. Apart from wheat, there is very limited use of improved seeds in maize, rice, and potatoes, and only local cultivars of other crops are grown. The use of chemical fertilizer is quite low and is mostly limited to accessible areas. The traditional method of maintaining soil fertility is through application of farmyard manure (FYM) or compost prepared by mixing manures with forest litter and crop residue. Composts applied to the fields are generally left in the open for several days and thus lose up to 52 per cent of the phosphorous content. Although such manures help replenish soil fertility, they cannot maintain fertility entirely when cropping intensities are as high as is currently the case. Because cereal crops dominate the existing cropping patterns and legumes play a rather minor role, the beneficial effects of the latter on soil fertility have been limited.

No on-farm operations are mechanised in the region, apart from in the Kathmandu and Pokhara valleys where a number of power tillers are in use. A pair of draft animals and a simple wooden plough are the usual means of land preparation on larger fields, while on narrow terraces only hand hoes are used. Virtually all other operations are carried out manually, including on-farm and off-farm transportation. Substantial mechanisation in the region is not feasible because of small farm sizes and their fragmentation, slope conditions, and limited access to the fields.

Cropping intensities are highly variable. Overall, the average cropping intensity is about 158 per cent on irrigated land and 130 per cent on unirrigated land (ADB 1982). The average yields of crops in the region are low and have reportedly declined over time. The average yields of maize, rice, wheat, millet, and potatoes in 1987/88 were estimated at 1.30, 1.97, 1.10, 0.91, and 6.49 metric tons per hectare respectively. The declining trends in crop yields have been caused mainly by cultivation of marginal lands, declining soil fertility, and general environmental deterioration.

The fruits commonly grown in the region are apples, pears, peaches, plums, and walnuts (at higher altitudes) and mandarins, limes, and lemons (in the mid-hills). Vegetables are grown in most areas for home consumption. Commercial cultivation of fruits and vegetables is usually not common because of transport and marketing problems. Fodder and fuelwood trees are common on upland terraces in most of the areas.

Livestock Production. Livestock production is an integral part of the farming system in the hills and mountains. It is regarded as the second major economic activity next to crop cultivation and contributes 20 to 27 per cent of the household income. The major roles of livestock are to provide manure and draft power for cultivation. In addition, livestock products such as milk, ghee, and meat contribute to the nutrition of the farming community. Livestock products in the form of ghee, wool, live animals, and hides are also traded for cash income.

Cattle, including yak and nak, buffaloes, goats, sheep, pigs, and poultry, are the major livestock species found commonly in the hills and mountains. It is estimated that in 1985/86, the livestock population in

the region consisted of about 4.3 million cattle, 1.9 million buffaloes, 3.4 million goats, 0.57 million sheep, 0.31 million pigs, and 6.4 million poultry (APROSC 1986). These figures indicate that the livestock density per unit of cultivated land in the region is one of the highest in the world.

Farmers in the region maintain mixed herds rather than pure herds. Livestock numbers generally increase with the landholding size, while livestock density per unit of cultivated land tends to decrease with the farm size. The different sources of feed for animals in the region are crop residues, fodder from farmland as well as forests, terrace wall vegetation, grazing on farmland (during off-crop season), community pastures, rangelands, and forests. Larger farms have more feed resources for stock -- in larger areas of land post-harvest residues are available for grazing and more crop by-products for feed. Small farmers, who make up the greatest percentage in the hills, cannot feed their animals from their land only and are, therefore, exerting the greatest pressure on communal feed resources - the forest and grazing lands.

Adult male cattle are used as draft animals (mainly for ploughing), whereas female cattle are kept mainly to breed replacement bullocks, although they also produce small quantities of milk. On an average, a pair of bullocks covers 2.08 ha of cultivated land in the hills and mountains. *Chauri* - a cross of yak and nak, with hill cattle and female buffaloes are primarily kept for milk production. Livestock productivity in general is low. The average per lactation milk yields of cows, buffaloes, and *Chauri* are estimated at about 300 litres, 400 litres, and 475 litres, respectively (ADB 1982 and APROSC 1981).

Livestock production in the hills and mountains is characterised by predominance of poor breeds, weak animal health and extension services, and poor feeding due to the dwindling feed resources. Shortage of fodder is the most critical aspect of livestock production in the region. The hill areas have the most pronounced fodder deficit, resulting in serious long-term damage to the environment. Deterioration occurs because livestock numbers are larger in the hills and the terrain, with its steep slopes and light soils, is very susceptible to erosion.

Forestry and Pastures. Forests, rangelands, and pastures constitute an integral part of the mixed farming system in the region. Forests supply fuelwood, timber, poles, bamboo, food items and other minor products to the farming households, fodder and bedding materials to livestock, and compost materials to croplands for the maintenance of soil fertility. In addition, forests in the catchment areas of streams, rivers, and lakes influence the supply of water for drinking and agricultural uses. Forests have an enormous role to play in protecting the fragile, hilly topography from natural calamities such as intense rain and preventing landslides and soil erosion.

LRMP has estimated that forests and grazing lands respectively cover about 41 and 14.5 per cent of the total physical area (113,390 sq. km.) in the hills and mountains. The situation is, however, worse than figures suggest because many areas of the hills, classified as forests, are in fact degraded wastelands with few or no standing trees. Similarly, most of the pasturelands are believed to be overgrazed and in poor condition. Climate, elevation, and slope aspects have the pronounced influence of the types of forest found in the area. At lower altitudes (below 1,000m), subtropical, deciduous, broad-leaved, hardwood forests, consisting of *Pinus roxburghii*, *Castanea indica*, *Schima wallichii*, *Alnus nepalensis*, and others, extend from 1,000m to 3,000m. Above this and up to 5,000m lies the alpine vegetation zone with forests of rhododendrons and shrubs and, in other places, areas of open grassland which are often overgrazed.

Various studies have estimated the extraction rates of major forest products and have argued that these rates, generally, exceed the carrying capacity of forests. According to MPFS (1988), timber and fuelwood extraction from forests for household use have been estimated at 0.07m^3 and 378 kg per capita per year, respectively. Rajbhandary and Shah (1981) estimated that about 72 per cent of the total feed requirements of livestock are supplied by off-farm resources (forest - 23%, rangelands - 34%, and wastelands - 15%). In addition, leaf litter, pine needles, and grasses are brought in as bedding for livestock and the resulting

compost/FYM is applied to croplands for maintaining soil fertility. Khandke et al. (1984) estimated that about 50 per cent of the litter production is removed annually from some forests in the hills. Minor forest products, such as tubers, fruits, shoots, mushrooms, honey, fish, bamboo, and medicinal herbs, supplement the diet as well as the family income of small farmers. However, data on quantification of these products are lacking.

A rapid expansion in human population with limited land resources and a heavy dependence of the farming system on forestry have led to overexploitation of forest resources (to meet the increasing demands for fuelwood, fodder, timber, bedding, and compost materials and depletion with the consequences of increased soil erosion, landslides, shortage of fuelwood, fodder, bedding and compost materials, decline in soil fertility, and eventual decline in agricultural productivity in the hills and mountains. The rapid deterioration of the ecological balance in the region and the need to reverse this trend has begun to be realised. The magnitude of the task and the lack of management capability and resources needed to rectify the situation make the problem extremely formidable.

STUDY AREAS AND THEIR RESOURCE BASE

The general characteristics (e.g., physical location, topography, soil, climate, infrastructure) of each study area along with their existing resource bases which include human resources, farmland, livestock, forestry, pastureland, and water resource, are discussed below.

General Characteristics

Physical Location, Topography, and Soil

Ekle *Gaon*, selected for the Crop-dominated Farming Systems' (CDFS) study, falls under ward number three of Dhuskun *Panchayat* (former) in Sindhupalchowk district and is one of the many mountainous districts of the Bagmati Zone in the Central Development Region (CDR) of Nepal (see the country map of Nepal). One of the principal all-weather roads of Nepal, called the Arniko Highway, which links Kathmandu and the Tibetan Autonomous Region of the People's Republic of China, passes through "Bahrabise" a commercial hubbub of the region which is 86km northeast of Kathmandu Valley. Ekle *Gaon* is located at about three hours walk to the east of Bahrabise. The study site covers a large and wide area ranging from 1,050m at the river side called *"beshin"* to *"lekh"*[*] at about 2,200m. However, the major settlement lies at an altitude from 1,600-1,700m.

The study site presents such a unique and long (about 1,200 m) uninterrupted series of verticle terraces of cultivated land with steep slopes (20-45°) that it interestingly delivers the message of a highly developed form of ethno-engineering. Soils are 50-100cm deep and well-drained. Loamy skeleton soils dominate the soil type in the area. The aspect of the site is generally south-facing.

Bhadaure village, chosen for the Horticultural Crop-dominated Farming System (HCDFS) study, is one of the many villages of ward number two of Naubise *Panchayat* (former) in Dhading district which is one of the eight hill and mountain districts of the Bagmati Zone under the Central Development Region (CDR). Naubise bazaar of Naubise *Panchayat* (former), which lies on the Pokhara Highway, is about 26km west of Kathmandu Valley and Bhadaure village is located 2 km east-north from Naubise bazaar. The site in general has a moderate slope with terraces from the top (1,050m) to the bottom (970m). The aspect of the area is west and south-facing. Soils are comprised of loam and silty loam with good drainage.

Yelung site, selected for the Livestock-dominated Farming System (LDFS) study, spreads over ward number five and six of Shyama Village *Panchayat* (former) and is adjacent to Jiri *Panchayat* (former) of Dolakha District, Janakpur Zone, (CDR). The northern part of Dolakha district borders the Tibetan Autonomous Region. Unlike many others, Shyama *Panchayat* (former) is quite large physically. It takes one complete day on foot even to cross one ward of the *Panchayat*.

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[*] *"Beshin" is a local name for the area which is characterised by a hot and humid climate with rice as the main cultivated crop. The area is mostly near streams and river banks. "Lekh" is the area characterised by cold (e.g., temperate, sub-alpine) climate where potatoes, wheat, and barley are the major crops.*

Yelung is three hours' walk from, and located to the east of, Jiri bazaar. The altitude of the site ranges from 1,600m to 3,000m with moderate to steep slopes of mountain terrains facing east to south-east. Well-drained, loamy textured soils are common in the area.

Climate

Ekle *Gaon* is characterised by a warm and temperate humid climate with a annual mean temperature of about 19°C and a total annual rainfall of about 2,230mm. The monthly minimum temperature ranges from 6°C in January to 19°C in July and the maximum temperature ranges from 18°C in January to 29°C in May. Rainfall is mainly concentrated in the monsoon months. About 90 per cent of the total annual rainfall occurs during June-September. Hailstorms in the area occur in two spells: first, during March-May, and second, during October-November, at an average interval of about two to three years. Frost, which occurs in some areas at higher altitudes during January-February, is not considered as a constraint to crop production by the farmers.

The climate of Bhadaure is subtropical and sub-humid, with an annual mean temperature of 21°C and total annual rainfall of about 1,585mm. The monthly minimum temperature ranges from 7°C in January to 21°C in July and the maximum temperature ranges from 19°C in January to about 35°C in June. The distribution of rainfall is highly seasonal. Of the total annual rainfall, about 88 per cent occurs during the five monsoon months (May-September). Hailstroms occur at an interval of three to four years, mostly during March-May and sometimes during October-November. Frost and snowfall do not occur in the area. However, dewdrops affect tomatoes and other vegetables during January-February.

The Yelung study site has a cool temperate climate. The annual mean temperature of the area is around 14°C. The monthly minimum temperature ranges from below freezing in January to about 17°C in July and the maximum temperature ranges from 13°C in January to about 23°C in June. The average annual rainfall of the area is about 2,139mm, of which about 87 per cent falls during the five monsoon months from May to September. Hailstorms occur in the area at an interval of three years, mostly during March-May. Both frost and snowfall are constraints for winter crops. Frost occurs during December-February while snowfall takes place during January-February at higher altitudes.

Existing Infrastructure

The CDFS study site is about six kilometres away from Barahbise and about eight kilometres away from Lamosangu, both of which are located on all-weather roadsides with four to five daily bus services to Kathmandu. There is a small farmer-managed irrigation system in the area which irrigates the lowlands in the monsoon only. The area has 11 *ghatta* (locally made water turbines), mostly seasonal for grinding grain.

Agricultural support institutions include a Small Farmers' Development Programme run by ADB/N, and a livestock Sub-centre at the site itself, and an agricultural sub-centre at Sunkoshi bazaar, about five km away in the same *Panchayat* (former). There is also one forest nursery very close to Barahbise and Lamosangu.

The HCDFS study site is about one kilometre away from the all-weather highway which connects Kathmandu with the *terai* and a number of western hill districts. There is a very high frequency of buses, trucks, and other vehicles on the highway and this facilitates the flow of goods and services in the area. There is a small farmer-managed irrigation system which irrigates most of the lowlands year round and some uplands in winter. There are two water turbines, one *ghatta*, and a hauler mill for grain processing.

Agricultural support services in the area are provided through ADB/N, the Commercial Bank, the Cooperative Society (*Sajha*), the agricultural sub-centre, and the livestock sub-centre located at Khanikhola, about three kilometres away from the site. In addition, there is one cooperative depot at Dharke (1.5 km), one private horticultural nursery at Khanikhola, one forest nursery at Misakot (6 km), and a horticultural farm at Dhunibeshi (3 km) in the Naubise *Panchayat* (former). Khanikhola and Dharke are the nearest market centres and most of the fruits and vegetables produced at the site are sold here. The site is relatively far better privileged in terms of accessibility and availability of inputs, services, and market facilities compared to other parts of the hills and mountains.

The LDFS or Yelung site is about five kilometres away from Jiri which is connected to Kathmandu by an all-weather road with two to three regular daily bus services. Access to the site from the roadhead at Jiri is only through foot trails. The site lacks irrigation facilities. There are about five *ghatta* for processing food grain.

The existing agricultural support services' institutions in the Shyama *Panchayat* (former) consist of one livestock sub-centre and three sub-branches of the Cherdung Cheese Factory which operate seasonally. There is one forest nursery in the *Panchayat*, and a livestock-breeding farm at Khimti in Ramechhap district which is about seven km away from the site. One livestock farm, one veterinary dispensary, and sub-branch offices of the ADB/N and Nepal Bank Limited, located at Jiri, also provide services to the farmers in the study area. Until now there is no institution, such as branches of the (AIC) Agricultural Inputs Corporation, even at Jiri, and this indicates that the priority of agricultural development is based on livestock development rather than on crops. The pattern and trend of agricultural institutional credit disbursement, as indicated by ADB/N records, also intimate the same.

Marketing Centres

Barahbise and Lamosangu are the two major marketing centres for the whole region of Sindhupalchowk district wherein Ekle *Gaon* lies. People come to these centres to buy essential goods and commodities ranging from clothing materials to food items.

In the case of the HCDFS site, Khanikhola and Naubise are the two major marketing centres in the area. However, many people from the study site go to Dharke - a small centre physically - but probably the biggest market centre in the area, particularly for vegetable growers who bring their fresh vegetables every morning (in season) carrying them on their backs. From there the vegetables are transported by vehicle to Kathmandu.

Jiri bazaar is the only marketing centre for the Yelung area. People come here with their surplus of agricultural products for sale and go back home with some essential daily commodities bought in Jiri. Livestock and their products (e.g., ghee, butter, meat, and eggs) are the major items that farmers sell in Jiri bazaar. Every Saturday there is a *hat*/bazaar in Jiri which remains active from 8.00 a.m to 12.00 noon or 1.00 p.m.

Resource Base

Human Resources

Family Size. The information on family size, economically active members, literacy rate, and population density are shown in Table 4.1. The average family size of the sample households is estimated at 5.07 members for Dhuskun, 7.13 members for Naubise, and 5.50 members for Yelung. Females constitute about 51 per cent of the family members in Dhuskun and Naubise and about 45 per cent in Yelung. In general, there is a positive correlationship between family size and landholding (Annex 2).

Education Status. The average literacy rate is computed at about 49 per cent, 64 per cent, and 48 per cent for Dhuskun, Naubise, and Yelung. Alhough the literacy rates for males and females are nearly equal in Naubise and Dhuskun, the female literacy rate is 20 per cent higher than males in Yelung (Annex 2). It is also found that, in general, the literacy rate is directly related to farm size.

Economically Active Members. The average number of economically active members per household ranges from 3.13 in Dhuskun to 3.77 in Yelung and 4.77 in the Naubise. The dependency ratio, i.e., the number of dependents per economically active member is highest in Dhuskun (0.62) followed by Naubise (0.49) and Yelung (0.46). The dependency ratio is found to be highest among large farmers in Naubise and among small farmers in Dhuskun.

Table 4.1: Demographic Features of Sample Households at Different Study Sites (Per Household Averages unless Indicated Otherwise)

Particulars	Dhuskun	Naubise	Yelung
Family Size (Persons):			
Male	2.50	3.50	3.00
Female	2.57	3.63	2.50
Total	5.07	7.13	5.50
Economically Active Members (No.)	3.13	4.77	3.77
Dependency Ratio	0.62	0.49	0.46
Literacy Rate (%)	49.00	64.00	48.00
Population Density per ha of Cultivated Land (Persons)	9.39	7.35	19.64

Source : Household Survey, APROSC 1989.

Note : Details in Annex 2.

Population Density. The population density per hectare of cultivated land is calculated at about seven persons for Naubise, nine persons for Dhuskun, and 20 persons for Yelung. The population density seems to be inversely related to farm size, i.e., the larger the farm size, the lower the population density. Thus, population pressure on cultivated land is highest among marginal farmers and lowest among large farmers.

Occupations. Agriculture is the major occupation of the majority of economically active population for all the study sites. Table 4.2 reveals that the proportion of economically active members with agriculture as their main occupation is highest in Dhuskun (90%) followed by Yelung (75%) and Naubise (69%). The rest of the economically active members are engaged in study, services, business, or other economic activities.

Besides the primary occupations, the economically active members of the sample households are also involved in secondary occupations such as wage labouring, cottage industries, and business. During slack season when family members do not have adequate work on the farm, they engage in secondary occupations in order to generate additional income for their families. Opportunities for secondary occupations are observed to be highest in Naubise.

Table 4.2: Occupations of the Economically Active Members of the Sample Households

Particulars	Dhuskun	Naubise	Yelung
Primary Occupations:			
Agriculture (%)	90.00	69.00	75.00
Study (%)	0.00	28.00	17.00
Services (%)	5.00	3.00	1.00
Other (%)	5.00	1.00	7.00
Secondary Occupations:			
Cottage Industry (%)	12.00	46.00	3.00
Wage Labouring (%)	10.00	3.00	15.00
Business (%)	1.00	1.00	2.00

Source : Household Survey, APROSC 1989.

Farmland

Land Use. Farmland is the major production resource at all the study sites. Table 4.3 shows land use patterns at household levels at the study sites. The total available land per household is observed to be highest in Naubise (1.31 ha) followed by Dhuskun (0.79 ha) and Yelung (0.44 ha). The proportion of available land used for crop cultivation is estimated at about 74 per cent in Naubise, 68 per cent in Dhuskun, and 63 per cent in Yelung. Homesteads of the sample households occupy about 18, 28, and 29 per cent of the total land at the three sites respectively. Homesteads also include the land area used for kitchen gardens. The rest of the land is occupied by orchards and *kharbari* in Naubise, by *kharbari* in Dhuskun, and by forests and *kharbari* in Yelung. Although the proportion of land occupied by homesteads is observed to be higher among small farmers, the actual area covered by homesteads is higher among larger farmers.

Table 4.3: Land Use at Household Levels at Different Study Sites

Particulars	Dhuskun	Naubise	Yelung
Total Land per Household (ha)	0.79	1.31	0.44
Land Use Pattern:			
Homestead (%)	28.00	18.00	29.00
Crop Cultivation (%)	68.00	74.00	63.00
Orchard (%)	0.00	3.00	0.00
Forest (%)	0.00	0.00	7.00
Kharbari/Fallow (%)	4.00	5.00	1.00

Source : Household Survey, APROSC 1989.

Operated Landholding. The average size of operated landholding is estimated at 0.97 ha in Naubise, 0.54 ha in Dhuskun, and 0.28 ha in Yelung (Table 4.4). While lowlands constitute about 40 and 31 per cent of the total cultivated land in Naubise and Dhuskun respectively, there is virtually no lowland at the Yelung site. The share of rented-in land in the operated landholding is about 20 per cent in Naubise, 13 per cent in Dhuskun, and 11 per cent in Yelung. Rented-out land is recorded at 0.07 ha per household among the large farmers in Dhuskun site only. The share of rented-in land in operated landholding is found to be higher among marginal and small farmers compared to medium and large farmers at all the study sites.

Irrigation Status of Operated Land. The survey revealed that irrigation facilities are mostly perennial in nature in Naubise and seasonal in Dhuskun. Table 4.5 reveals that almost all the lowlands are perennially irrigated and about 20 per cent of the uplands are seasonally irrigated in Naubise, whereas only lowlands are seasonally irrigated in Dhuskun. No irrigation facilities exixts in the Yelung site.

Table 4.4: Average Size of Operated Landholdings at Different Study Sites

Particulars	Dhuskun	Naubise	Yelung
Operated Landholding:			
Lowlands (ha)	0.17	0.39	0.00
Uplands (ha)	0.37	0.58	0.28
Total Operated (ha)	0.54	0.97	0.28
Share of Rented-in Land (%)	13.00	20.00	11.00

Source : Household Survey, APROSC 1989.

Table 4.5: Irrigation Status of Operated Land at Different Study Sites

Particulars	Dhuskun	Naubise	Yelung
Lowlands :			
Perennially Irrigated (%)	0.00	98.00	0.00
Seasonally Irrigated (%)	100.00	2.00	0.00
Uplands :			
Seasonally Irrigated (%)	0.00	20.00	0.00
Rainfed (%)	100.00	80.00	100.00

Source : Household Survey, APROSC 1989.

Fragmentation of Operated Landholding. The average number of parcels per farm is found to be highest in Yelung (12) followed by Naubise (5) and Dhuskun, (4). The average size of parcels is computed at about 0.21 ha in Naubise, 0.13 ha in Dhuskun and, 0.02 ha in Yelung (Table 4.6). The size of parcels seems to be positively related to farm size at all the study sites. The average distance to a parcel of lowlands from the homesteads is estimated at about 18 minutes' walk in the case of Naubise and 42 minutes walk in Dhuskun. Similarly, the average distance in the case of uplands is calculated at about 20, 15, and 31 minutes' walk from a parcel to the homestead at Naubise, Dhuskun, and Yelung respectively.

Table 4.6: Fragmentation of Operated Land and Its Distance from Homesteads

Particulars	Dhuskun	Naubise	Yelung
Number of Parcels per Household:			
Lowlands	1.34	2.27	-
Uplands	2.72	2.37	11.90
Total	4.06	4.64	11.90
Size of Parcels (ha):			
Lowlands	0.13	0.17	-
Uplands	0.14	0.24	0.02
Average	0.13	0.21	0.02
Distance from Homesteads (min):			
Lowlands	42.00	18.00	-
Uplands	14.00	20.00	31.00

Source: Household Survey, APROSC 1989

Tenancy Systems. The information on the number of tenants and the tenancy systems at different study sites is presented in Table 4.7. Tenants, including owner-cum-tenants, account for about 40 per cent of the sample households in Naubise, 30 per cent in Dhuskun, and 23 per cent in Yelung. The remainder of sample households at all the study sites are exclusively owner-operators, except for one landless household in Dhuskun. While 50 per cent of the tenants were reported to have received tenancy rights for their rented-in lands in Naubise, none of the tenants have received tenancy rights in Dhuskun and Yelung. Thus, tenant farmers without tenancy rights do not have any assured incentive for long-term investment in the rented-in land because such land can be taken back by the landlords any time. Share-cropping is the most common system of tenancy in Naubise and Dhuskun. In this system, 50 per cent of the annual crop output is given to the landlords as rent for rented-in land by the tenants. In most cases, tenants themselves manage and supply all kinds of inputs required for the production of crops. Sometimes, the landlords share the cost of some inputs such as seeds and fertilizers. The fixed rent system of tenancy predominates in the Yelung site and is also found to some extent in Naubise. In this system, tenants have to pay predetermined rent, either in cash or kind, to the landlords for the rented-in land and, in return, they are entitled to receive all the crop outputs. Tenants have to bear all the input costs incurred in the production of crops.

Information on crop production in terms of their input-output coefficients, including cropping pattern, cropping intensity, FYM/compost and chemical fertilizer application, and crop yields are presented in Annex 3.

Table 4.7: Tenants and Tenancy Systems at Different Study Sites

Particulars	Dhuskun	Naubise	Yelung
Total Number of Sample Households	30	30	30
Exclusive Owner Operators (No.)	20	18	23
Owner-cum-Tenant Operators (No.)	8	10	7
Exclusive Tenant Operators (No.)	1	2	0
Landless (No.)	1	0	0
Tenancy System:			
- Share-Cropping (% of tenants)	100	67	0
- Fixed Rent System (% of tenants)	0	33	100

Source: Household Survey, APROSC 1989.

Livestock

Livestock Holding Size. Livestock are a very important part of the total resource base that the farmers hold. On average, a farmer maintains 3.39 head of cattle, 1.6 buffaloes, 2.44 goats, and 2.23 poultry (including 0.46 pigeons) in Naubise, whilst the figures for Dhuskun are 2.2, 0.86, 2.73, and 3.70, and for Yelung 2.2, 2.33, 2.96, and 2.20 respectively, including 0.07 sheep and 4.27 head of *chauri* (Table 4.8). Table 4.9 and 4.10 indicate that there is a positive correlationship between farm family size and livestock holding, and, apart from in the case of marginal farmers in Dhuskun, the per capita livestock holding size is more or less the same.

Table 4.8 reveals that all farmers at all study sites, irrespective of their farm size, maintain a mixed herd where cattle, buffaloes, and goats seem to be the most popular type of animal raised. The farmers in Yelung also maintain sheep and *chauri* in addition to other types of animal. It is interesting to note that irrespective of the farm size all farmers are maintaining virtually the same number of animals at Yelung. This implies that livestock raising may be a function of the amount of fodder supply from public land.

Cattle, including *chauri*, constitute about 60 per cent of the total LSU and appear to be the most important animals to farmers at all study sites, followed by buffaloes, sheep, and goats. Needless to say, *chauri* are the favourite animals of the farmers in Yelung and these alone account for about 45 per cent of the total LSU.

Table 4.8: Average Livestock Holding Size Per Household By Type of Animal and Study Site

(in No.)

Animal	Dhuskun	Naubise	Yelung
Cattle	2.20	3.39	2.20
Buffalo	0.86	1.67	2.33
Goat	2.73	2.44	2.96
Sheep	-	-	0.07
Poultry	3.70	1.77	2.20
Pigeon	-	0.46	-
Chauri	-		4.27

Source : Household Survey, APROSC, 1989.

Table 4.9: Average Livestock Holding Size Per Household by Farm Size and Study Site

(in LSU)

Farm Size	Dhuskun	Naubise	Yelung
Marginal	1.60	-	7.17
Small	2.82	3.15	7.07
Medium	2.60	3.17	8.71
Large	4.24	5.74	-
Overall	2.70	4.19	7.41

Source : Household Survey, APROSC 1989.

Livestock Density. The average livestock densities per hectare of cultivated land are computed at 4.32, 5.00, and 26.64 LSU for Naubise, Dhuskun, and Yelung respectively. Table 4.10 clearly depicts that livestock farming is more important to small and marginal farmers than to larger farmers.

The highest determining factor for livestock raising in the hills and mountains is the fodder supply from public land or common property (e.g., forest, pastureland) rather than private land (e.g., cultivated land), although family size also does influence the holding size positively. Although the livestock holding size for larger farmers with a larger landholding size (Table 4.9), the density of livestock per hectare of cultivated land by farm size is just the opposite (Table 4.10). The densities among marginal and small farmers are more than two or three times higher than those of middle and large farmers. This clearly indicates that common property resources are much more important to small and marginal farmers than to larger farmers, apart from in Naubise where the CPRs virtually do not exist.

The importance of livestock raising is much higher in Yelung and Dhuskun than in Naubise as indicated by the fact that the share of livestock to total cash farm income are estimated at 98, 47, and 10 per cent respectively (Annex 4, Table 1). This has a direct relevance to the availability of fodder supply from the CPRs. If one hectare of CPR is available for about 2.5 livestock units (LSU) in Yelung then the estimated figures for Dhuskun and Naubise are about 5.0 and 20.0 LSU respectively*.

Table 4.10 also indicates that as the altitude of an area increases so does the importance of livestock raising. This is manifested by the livestock raising situation in Naubise, Dhuskun, and Yelung where the elevation is estimated at 1,000m, 1,000-2,500m, and 1,600-3,000m respectively.

Table 4.10: Livestock Density Per Unit of Cultivated Land by Farm Size and Study Site

Owner-cum-Tenant Farm Size	Dhuskun		Naubise		Yelung	
	Average Size of Operated Landholding (ha)	Livestock Density (LSU/ha)	Average Size of Operated Landholding (ha)	Livestock Density (LSU/ha)	Average size of Operated Land-holding (LSU/ha)	Livestock Density (LSU/ha)
Marginal	0.12	13.33	-	-	0.15	51.21
Small	0.40	7.05	0.36	8.75	0.37	19.11
Medium	0.73	3.59	0.79	4.01	0.63	13.83
Large	1.19	3.56	1.60	3.59	-	-
Overall	0.54	5.00	0.97	4.32	0.28	26.64

Source : Household Survey, APROSC 1989.

Livestock Production

Except for a few cross-breeds all animals are local and indigenous and thus their performances are genetically poor. Livestock production is also influenced by spatial and temporal dimensions. Buffaloes, for instance, which are kept mainly for milk production, produce about 1,065 litres per 300 days lactation in Naubise and 595 litres in Yelung during the same lactation period. The proportion of cross-breed buffaloes is much higher in the former study site than in the latter. The milk yield rate is not reported in the case of Dhuskun, not because there were not many animals in the study area but because no single sample household had a buffalo at the milking stage. Table 4.11 also reveals that cows produce a very small amount of milk.

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* It is roughly estimated that about 200 households are using 600 ha of CPRs in Yelung and 240 and 245 farm households are estimated to have used 130 ha and 50 ha of CPRs at Dhuskun and Naubise study site respectively.

This is the reason why farmers prefer cattle for draft power and manure production. Because it is seasonal in nature, almost two-thirds of the total annual milk production takes place during one-third of the year (June/July - September/October).

Goats and sheep are also important animals and are raised mainly for meat and wool. Although goats are small in size (about 20 - 25 kg live weight at maturity) and slow in growth, they are prolific and hardy - suitable for the rough terrain of the mountains. Unlike in many other countries, goats are not maintained for milk production in Nepal. Sheep and goats are also being used as pack animals, particularly in the high mountains. They can carry a load of 5-10 kg. Both the wool (about 0.3-1.0 kg per animal per year) and meat production (25-30 kg live weight of adult animals) of sheep are very low owing to inadequate nutrition level and poor genetic make up.

Table 4.8 reveals that a few poultry are raised by the households at all study sites. However, their egg and meat production is very low because they are of indigenous breed. On an average, one layer produces 30-50 eggs per year and the live weight of one bird is 1.0-1.5 kg.

The sample households did not report keeping *yak*, which can be found at high altitudes, ranging from 12,000 - 15,000/16,000 ft, and do not generally descend below 10,000 ft. But *chauri*, a cross-breed of *yak/nak* and hill cattle, seems to be quite a popular animal, particularly in Yelung. In this area, *chauri* are kept mainly for milk production in small herds of 10 animals, otherwise, as per the farmers' version, they are not economical since, unlike in many other areas, *chauri* are not used for transportation purpose. Farmers were found to have maintained a maximum herd of 22 *chauri* (all adult females) mainly for milk production. Table 4.11 indicates that, on average, one female *chauri* produces about 300 litres of milk per 180 days lactation period.

Table 4.11: Milk Yield Per Lactation Per Animal By Study Site

(in Litres)

Animal	Dhuskun	Naubise	Yelung	Lactation Per for all study sites (days)
Cattle	125	428	254	204
Buffalo	-	1065	595	300
Chauri	-	-	307	180

Source : Household Survey, APROSC 1989.

Animal Feed

Animal feed, in the context of the hills and mountains, has been recognised as probably the most crucial element behind the low productivity of livestock. They remain half-fed most of the year, except during summer and the rainy season (June/July to September/October), particularly in the case of the Naubise and Dhuskun sites. About 80 per cent of the total feed supply is available during this time period in Naubise and under 45 per cent in the Dhuskun area. It is a difficult to give this type of account in the case of Yelung because it is cumbersome to assess both the quality as well as the quantity of green fodder made available through grazing during that time period, since it accounts for a major share of the total feed supply. However, based on observation and discussion with key informants, there is abundant green fodder during that time period and some proportion of the fodder is wasted due to lack of conservation practices.

Green fodder is simply cut and carried from private lands during summer and the rainy season when green grasses are adequately available. However, this also takes place on public land, for short time periods, when the demand for labour for agricultural activities is highest. This prevents the grazing of animals, particularly in the Naubise and Dhuskun areas. Farmers, instead, prefer to resort to stall-feeding practices which demand less labour than grazing, especially when grasses are widely available. An increase in the rate of school-going children has also adversely affected livestock farming and this problem is compounded because one self-help activity, a traditional indigenous management practice that saves labour by the co-herding the animals of four or five farm households by one individual on a rotation basis, has slowly ceased to exist.

The intensity of stall-feeding is, in fact, increasing over time because of intensive cultivation practices to meet increased food demands. Cultivated land in the past used to be kept fallow at least for four or five months in a year and this permitted grazing. Currently, grazing takes place mainly on forest and pastureland during winter in Dhuskun and Naubise. Whereas in Yelung, grazing takes place almost throughout the year.

Table 4.12 depicts that the livestock production in Naubise virtually depends on private lands (e.g., cultivated land, homesteads, etc) which contribute about 90 per cent of the total feed supply in the form of green fodder (e.g., grasses, weeds, and tree fodder), dry fodder (e.g., crop by-products - sprays, stover, etc), and concentrated feed - *khole**. The table also implies that as the elevation of the area increases the proportion of animal feed supply from private land decreases and the contribution of common or public land (e.g., forest, pastureland) increases (from about 10 per cent in Naubise to 90 per cent in Yelung) and so does the importance of livestock keeping. Therefore, the livestock production system is closely associated with accessibility to forest and pastureland which provide low-cost inputs in the form of green fodder. This is further corroborated by Table 4.13; the share of concentrated feed- a high cost input - is very low (less than 1%) in the livestock-dominated farming system study sites, compared to 'Naubise' (horticultural crop-dominated farming site) where the figure is 10 per cent of the total feed supply.

Table 4.12 also clearly shows that the animal feed deficit is a general norm in all study sites, ranging from one-third to one-half of the total requirement. For detailed information regarding fodder supply from different sources, and the assumptions made for computing the demand and supply of animal feed, see Annex 5.

Table 4.12: Total Annual Animal Feed Supply Per Household By Source and Study Site

(TDN in kg)

Source of Supply	Dhuskun	Naubise	Yelung
Cropland	1334 (68)	2193 (90)	572 (9)
Forest/Pastureland [1]	619 (31)	220 (9)	5629 (90)
Market [2]	11 (1)	11 (1)	33 (1)
Total Feed Supply	1964 (100)	2424 (100)	6234 (100)
Total Feed Requirement	2916	4525	8003
Balance (in percentage)	(-33)	(-46)	(-22)

Source: Household Survey, APROSC 1989.

Note : Figures in parentheses are percentages of the total feed supply. Negative figures indicate deficit.

* About 1kg of cereal grain (e.g., maize, wheat, paddy, millet, barley) is boiled with 4 or 5 litres of water and some salt-called khole-and is given to milking and draft animals.

Table 4.13: Proportion of Animal Feed Supply by Types of Feed and Study Site

- TDN in kg
- proportion in %

Types of Feed	Dhuskun		Naubise		Yelung	
	TDN	Proportion	TDN	Proportion	TDN	Proportion
Green Fodder	738	24.9	591	41.5	858	13.7
Dry Fodder	1845	62.3	369	25.9	242	3.9
Concentrates	54	1.8	244	17.0	41	0.7
Grazing	327	11.0	220	15.6	5093	81.7
Total	2965	100.0	1424	100.0	6234	100.00

Source : Household Survey, APROSC 1989.

Animal Disease

Internal parasitic diseases are more prevalent and serious and directly affect the productivity of animals in terms of reduced amount of milk and meat. The mortality rate of particularly small ruminants is very high because of this disease. Some other virus diseases also cause multiple deaths of animals and poultry and occur from time to time because of weak government, animal-health support programmes.

Forestry

There is a very limited area under forests at the Bhadaure study site. Only about two hectares of forest are being freely utilised. Most of the 50 ha of accessible forests (Annex 6) are either completely controlled by the Government or *Panchayat* (former). This is so because of the degraded vegetative cover of the forest which is now undergoing a process of improvement. There are small patches of forest, including the *Baluwa danda, Machendra,* and *Kaldhara forests.*

The crop-dominated farming system study site, observed in Ekle *Gaon*, seems to be relatively better off as far as the existence of a forest resource base is concerned. Unlike Naubise *Panchayat* (former), land use data in Dhuskun were not available. However, efforts were made to estimate the area under forests with the help of key informants, and thus the validity of the data presented here is subject to confirmation. Altogether about six patches of forest covering an area of about 130 hectares seem to be accessible or under use in the study site. Out of these three patches, 86 ha are categorised as *Panchayat* (former) protected forest (PPF), a *Panchayat* (former) forest (PF), covering about 22 ha of the area, and the remaining two patches of about 25 ha are informally recognised as community forest. Most of the area under PPF has been newly afforested whereas the PF (completely controlled by the former *Panchayat*) has about 50 per cent of good vegetative cover. At present, the distance to the forests from the villages ranges from one to five kilometres. Forests are the source of fodder, fuelwood, and timber. Some of the local names of the available trees are - *khashru, ghurbiso, jhingaune and katus* for fodder; *babiyo, kimbu, salimo, furke*, for green grass; *angeri, gurans, mahuwa*, for fuelwood trees; and *utis, chilaune, sal, lapsi, faledo*, for timber. *Banmara* is a widely available plant which can be used only as bedding material for livestock.

1) It is estimated that about 10 per cent and 20 per cent of the total feed requirements (1,080 kg TDN per LSU per year) in Naubise and Dhuskun respectively have been met through grazing on fallow land, in forests, on grazing land. In Yelung the figures are estimated at 50 per cent in the case of cattle, buffaloes, sheep, and goats and about 80 per cent in the case of *chauri* which remain on grazing land and alpine pastureland throughout the year.

2) Some cereals and pulses are also being purchased from the market for the animals feed.

Yelung study site is particularly rich in common property resources (e.g., forest, pastureland). However, it has become extremely difficult to estimate the area under the resources due to the unavailability of scientifically measured data. In this area, forest and pastureland are synonymous, therefore they will be discussed in the subsequent section - although some dense forests do exist in this area, for example - Cherdung forest with about 200 hectares is at a distance of about 2.3 hours' walk.

Pastureland/Grazing Land

There is virtually no pasture or grazing land at Naubise site. Animals graze along the stream and river banks. All available land has already been brought under cultivation. In the case of Dhuskun site, there are small and sporadic patches of pasture and grazing land inside the forest area itself and they are being intensively used because of the lack of reasonably adequate areas for animal grazing. Therefore, both study sites face serious problems in livestock grazing. The available limited area, suitable for grazing land, is also slowly being destroyed and used for cultivation.

However, the Yelung study site still has a large proportion of pastureland and meadows in relation to its total physical area. According to information from key informants, pastureland accounts for over 600 hectares. '*Khark*', a local name for pastureland meadows, provides a good source of animal feed in the form of green grass. This is being used throughout the year whenever and wherever possible and tree fodder has been considered a supplemental feed, particularly during winter when fodder scarcity arises. '*shiru*' and '*khashru*', local names for green grass and tree fodder respectively, are widespread. Some clover grasses are also sporadically available, particularly during the summer and rainy seasons. This is the residual effect of efforts that were made 10-12 years ago to improve the whole pastureland, through broadcasting clover seeds, by the Swiss Development Cooperation (SDC)-assisted government livestock development farm located at Jiri.

The livestock-dominated farming study site (Yelung) is a cluster of a few villages which are surrounded by forests and pastureland within a distance of a quarter of an hour to one hours' walk. A rough estimation indicates that about 2,000-2,500 ruminants (e.g., cattle, buffaloes, sheep, goats, and *chauri*) are using the whole pastureland area. This indicates that one hectare of pastureland is available for about four ruminants or about 2.5 LSU.

Water Resources

Yelung and Naubise sites appear to be better off in water resources compared to Dhuskun. There is no major river in any of those study areas. A small river system, consisting of Mahesh *Khola**, Khani Khola, and Naubise Khola, which are permanent in nature, are located within the periphery of one to two kilometres in distance from the Naubise study site. However, Mahesh *Khola* appears to be of prime importance to the people as far as the use of water is concerned. Dabi *Khola*, in the Dhuskun area, flows along the lower part (at an altitude of about 1,100m) of the study area which is three to four kilometres in distance from the main villages (at an elevation of 1,600m-1,800m) where the majority of the people reside.

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* Khola is a local name for a small river which is permanent in nature.

There are also two or three small streams that can be used only during summer or the rainy season, because they are temporary in nature. Khimti, Yelung, and Lohara Kholas are the principal small rivers in the Yelung area. However, Yelung Khola which flows from the centre of the study area, is most important to the people since it can be used throughout the year. At present, the khola is being used to run '*ghattas*' (water mills) and to irrigate land. In addition, there are a few streams which are used seasonally.

The available water resources are used for drinking water, irrigation, and to run water mills ('*ghatta*') in all study areas. Power generation has not taken place so far in any area. The existing water resources are yet to be meaningfully tapped.

5

PRODUCTION FLOW : LINKAGES AMONG COMPONENTS OF MOUNTAIN FARMING SYSTEMS

Backward and Forward Linkages

Crops (including horticultural crops), livestock, and forestry have been identified as the three most essential components of the mountain farming systems in all three study sites. A farmer or a household manoeuvres these three components with his/its management skills in order to extract outputs that can be generated from each component. Market forces are more recent influences that shape a particular type of farming system in the mountains. These components are so much interwound that one can hardly think of a farming system in the absence of one component. The only fact is that the magnitude of the attributes of these components differs as per the variation in altitude, microclimates, and other socioeconomic settings. This section of the chapter, thus, will attempt to analyse the direction and magnitude of the production flow of inputs and outputs from one component to another with the help of matrices. The implications of variations in production flow in different study sites will be dealt with in subsequent sections and chapters as well. Three different types of matrices (presented in Tables 5.1, 5.2, and 5.3) form the basis for discussion in this section.

Crops and Livestock

A strong linkage does exist between the crop and livestock sectors of a farming system; the production of one component without the other is either very difficult or unsustainable in the mountains. Crops cultivated in farmland provide a very important source of fodder to animals. This is depicted clearly in Tables 5.1, 5.2, and 5.3. Weeds and other grasses, including tree fodder derived from farmland, form green fodder. However, crop by-products (e.g., paddy, wheat, barley and millet straw, maize stover, etc), called dry fodder, also constitute a major source of animal nutrition. In addition, cereal grains which come from the crop sector are also fed to selected productive animals (e.g., milch/draft animals) in order to derive more milk and animal power. If a farmer at Naubise provides 275 kg of grain (e.g., rice, maize, wheat, barley, millet, etc) to animals in the form of concentrated feed then the figures for Dhuskun and Yelung are estimated at 51 kg and 9 kg respectively (Tables 5.1, 5.2, and 5.3). Livestock farming is heavily dependent upon crops (or farmland), particularly in the Naubise area where about 90 per cent (2,193 kg TDN) of the total animal feed comes from farmland alone.

The livestock component also provides essential inputs to crops for their production and development. In this respect Tables 5.1, 5.2, and 5.3 are self-explanatory. Livestock, in fact, supply manure which is the only source for maintaining soil fertility, particularly in Yelung and Dhuskun where chemical fertilizers are either non-existent or little used. Hence, crop production without livestock rearing is extremely difficult in the mountain region. As indicated by the matrices, the livestock component provides fresh dung (manure) to the tune of 12.8 MT, 8.1 MT, and 10.1 MT in Naubise, Dhuskun, and Yelung respectively. The present manure application rate per hectare of cropped area is extremely high in Yelung (31.5 MT), whereas the figures for Dhuskun and Naubise are only 8.8 MT and 8.0 MT respectively.

Another very relevant attribute from livestock to crop production is animal power which is mainly used for land preparation. The use of animal power varies from one study site to another, depending upon the cropping pattern and intensity, soil type, soil moisture content, and availability of bullock power. An estimation based on field data indicates that on an average a farm household uses a total of 98 animal days at Naubise, 56 animal days at Dhuskun, and 24 animal days at Yelung. Whereas the number of animal days per hectare of cropped area is calculated at 61 each for Naubise and Dhuskun and 75 for

Table 5.1: Matrix Showing Linkages among the Components of the Crop-dominated Farming System at the Dhuskun Site (Per Average Household Per Annum)

Production Sectors	Flow Direction	Consumption Sectors				
		Crops	Livestock	Forest/Pasture	Household	Market
Crops (0.54 ha)						
- Cereals (1241 kg)		34 kg (seed)	51 kg (conc.)	-	1049 kg	61 kg[1] 27 kg (rent)
- Oilseeds (5 kg)	▶			-	2 kg	19 kg
- Crop residue (1850 kg)		-	-	-	72 kg (fuel)[3]	(wage)[2]
- Compost materials (127 kg)		-	1778 kg	-	-	3 kg
- Tree fodder (100 kg)		127.0	-	-	-	-
- Grass fodder (3392 kg)		kg -	100 kg 3392 kg	-	-	- -
		-				-
Livestock (2.70 LSU)						
- Milk (28 litres)	▶	-	-	-	28 litre	-
- Fresh manure (8,898 kg)		8119	-	779 kg	-	-
- Draft power (56 ad)		kg	-	-	-	-
- Live animals (Rs 63)		56 ad	-	-	-	Rs 63
		-				
Forest/Pastures (0.54 ha)						
- Tree fodder (61 kg)		-	61 kg	-	-	-
- Grass fodder (2219 kg)		-	2219 kg	-	-	-
- Grazing (327 kg TDN)[4] or (686 hrs)	▶	-	327 kg TDN	-	-	-
- Compost material (320kg)		320 kg	-	-	-	-
- Bedding materials (757 kg)		-	757 kg	-	-	-
- Fuelwood (2572 kg)		-	-	-	2572 kg	-
Household (5.07 family size)						
- Labour (520 md)	▶	161 md	265 md	-	-	Cash (Rs 3893[5]) (94 md[6])
Market						
- Credit (Rs 1036)		Rs 145	Rs 300	-	Rs 591	-
- Off-farm income (Rs 2569)		-	-	-	Rs 2569	-
- Cereals (76 kg)		3 kg	13 kg	-	60 kg	-
- Fertilizer (33 kg)	▶	(seeds)	(conc.)	-	-	-
- Labour (3 md)		33 kg	-	-	-	-
- Animal purchases (Rs 52)		3 md	-	-	-	-
- Other inputs (Rs 52)		-	Rs 52	-	-	-
- Consumer goods and services (Rs 2379)		- -	Rs 52 -	-	Rs 2379	-

Note : TDN = Total Digestible Nutrient; conc. = concentrated feed; md = mandays; ad = animal days.
See page 49 for remarks and footnotes related to all three matrices (Tables 5.1, 5.2, and 5.3) displayed at the end of this chapter.

Table 5.2: Matrix Showing Linkages among the Components of the Horticultural Crop-dominated Farming System at Naubise Site (Per Average Household Per Annum)

Production Sectors	Flow Direction	Consumption Sectors				
		Crops	Livestock	Forest/ Pasture	Household	Market
Crops (0.97 ha)						
- Cereals (2658 kg)		74 kg(seeds)	275kg(conc)	-	1662 kg	373 kg+95 kg (rent)[1]
- Oilseeds (29 kg)		1 kg	-	-	8 kg	179 (wage)[2]
- Sugar cane (596 kg)		162 kg	-	-	24 kg	20 kg
- Potato (176 kg)		-	-	-	80 kg	410 kg
- Fruits (647 kg)		-	-	-	291 kg	96 kg
- Vegetables (2892 kg)		-	-	-	150 kg	
- Crop residue (3591 kg)		-	2883 kg	-	708kg(fuel)[3]	356 kg
- Compost materials (820 kg)	▸	820 kg	-	-	-	2741 kg
- Bedding materials (533 kg)		-	533 kg	-	-	-
- Tree fodder (497 kg)		-	497 kg	-	-	-
- Grass fodder (4275 kg)		-	4275 kg	-	-	-
- Fuelwood (2092 kg)		-	-	-	2091 kg	-
- Roofing materials (69 kg)		-	-	-	69 kg	-
Livestock (4.19 LSU)						
- Milk (407 l)		-	-	-	335 litre	72 litre
- Fresh manure (13,297 kg)	▸	12,811 kg	-	486 kg	-	-
- Draft power (110 ad)		98 ad	-	-	-	12 ad
- Live animals (Rs 682)		-	-	-	-	Rs 682
Forest/Pastures (0.20 ha)						
- Compost materials (426 kg)		426 kg	-	-	-	-
- Bedding materials (650 kg)	▸	-	650	-	-	-
- Grazing (220 kg TDN)[4] or (298 hrs)		-	220 kg TDN	-	-	-
- Fuelwood (1417 kg)		-	-	-	1417 kg	-
Household (7.13 family size)	▸					Cash (Rs 17,076[5])
- Labour (724 md)		270 md	224 md	-	-	230 md[6]
Market						
- Credit (Rs 5818)		Rs 2093	Rs 1300	-	Rs 2425	-
- Off-farm income (Rs 5421)		-	-	-	Rs 5421	-
- Cereals (147 kg)		8 kg	12 kg (cont)	-	127 kg	-
- Potato (29 kg)		29 kg	-	-	-	-
- Meat (5 kg)		-	-	-	5 kg	-
- Vegetables (9 kg)		Rs 183	-	-	9 kg	-
- Fertilizer (340 kg)	▸	340 kg	-	-	-	-
- Pesticides (Rs 361)		Rs 361	-	-	-	-
- Labour (71 md)		71 md	-	-	-	-
- Draft power (34 ad)		34 ad	-	-	-	-
- Animal purchase (Rs 1301)		-	Rs 1301	-	-	-
- Other (Rs 618)		-	Rs 618	-	-	-
- Other inputs (Rs 662)		-	Rs 662	-	-	-
- Consumer goods and services (Rs 9355)		-	-	-	Rs 9355	-

Table 5.3: Matrix Showing Linkages among Components of the Livestock-dominated Farming System at Yelung Site (Per Average Household Per Annum)

Production Sectors	Flow Direction	Consumption Sectors				
		Crops	Livestock	Forest/Pasture	Household	Market
Crops (0.28 ha)						
- Cereals (312 kg)	▶	17 kg	9 kg	-	282 kg	4 kg rent[1]
- Potato (348 kg)	▶	68 kg	-	-	249 kg	31 kg
- Crop residue (526 kg)	▶	-	510 kg	-	16 kg (fuel)[3]	-
- Compost materials (48 kg)	▶	48 kg	-	-	-	-
- Tree fodder (187 kg)	▶	-	187 kg	-	-	-
- Grass fodder (4568 kg)	▶	-	4568 kg	-	43 kg	-
- Fuelwood (43 kg)	▶	-	-	-		-
Livestock (7.41 LSU)						
- Milk (608 litre)	▶	-	-	-	191 litre	147 litre
- Meat (16 kg)	▶	-	-	-	16 kg	-
- Fresh manure (26,673 kg)	▶	10,142 kg	-	16531 kg	-	-
- Draft power (24 ad)	▶	24 ad	-	-	-	-
- Live animals (Rs 682)	▶	-	-	-	-	Rs 682
Forest/Pastures (3.0 ha)						
- Compost materials (548 kg)	▶	548 kg	-	-	-	-
- Bedding materials (797 kg)	▶	-	797 kg	-	-	-
- Tree fodder (5202 kg)	▶	-	5202 kg	-	-	-
- Grass fodder (987 kg)	▶	-	987 kg	-	-	-
- Grazing (5,093 kg TDN)[4] or 2018HRS	▶	-	5083kg TDN	-	-	-
- Fuelwood (2,977 kg)	▶	-	-	-	2977 kg	-
Household (5.5 family size)						
- Labour (969 md)	▶	66 md	777 md	-	-	Cash (Rs 995 126 md[6])
Market						
- Credit (Rs 4,144)	▶	-	Rs 3034	-	Rs 1010	-
- Off-farm income (Rs 4,621)	▶	-	-	-	Rs 4621	-
- Cereals (394 kg)	▶	-	39 kg (conc)	-	355 kg	-
- Vegetables (7 kg)	▶	-	-	-	7 kg	-
- Meat (4 kg)	▶	-	-	-	4 kg	-
- Other inputs (Rs 25)	▶	-	Rs 25	-	-	-
- Animal purchase (Rs 2,955)	▶	-	Rs 2955	-	-	-
- Consumer goods and services (Rs 4,632)	▶	-	-	-	-	-
Other (Rs 198)	▶	-	-	-	Rs 4632	-
	▶	-	Rs 198	-	-	-

Yelung. Another reason behind higher use of animal days per hectare of cropped area in Yelung is the lower (115) cropping intensity compared to Dhuskun (171) and Naubise (165). These figures also imply that the use intensity of animal power, perhaps, largely depends on the availability of draft animals. A farmer in Naubise, for instance, keeps 0.53 bullocks, for draft power and in Dhuskun and Yelung farmers keep 0.56 and 1.07 bullocks respectively for the same purpose.

Crops and Forestry

As such, there is no direct two way link (production flow) between crop and forestry components. Compost material particularly comes to crop production from the forestry sector and is again a vital source of plant nutrients and its collection and application depends upon a number of factors. Some of them are availability of family labour and the extent of its necessity, depending on total cropped area, cropping pattern, and the magnitude of the availability of compost material. These can be the reasons for the difference in application rates in various localities in the mountains. On an average, one farm household with 0.97 ha of land is estimated to have applied 426 kg of compost material in Naubise and 320 kg and 548 kg in Dhuskun and Yelung on 0.57 ha and 0.28 ha of landholdings respectively.

Livestock and Forestry/Pastureland

There is a strong relationship between livestock and forestry/pastureland. The latter sector provides green fodder (e.g., tree fodder, grasses) and bedding materials required for animals. As Tables 5.1, 5.2, and 5.3 reveal, on an average, a farm household is estimated to have extracted about 800 kg, 750 kg, and 650 kg of bedding materials from the forests in Yelung, Dhuskun, and Naubise respectively. Grazing on forest/pastureland constitutes a major source of animal feed, particularly at the Yelung site where about four-fifths of the total animal feed are derived from this sector due to the existence of good alpine pastureland and meadows (Table 4.13).

The importance of forest and pastureland in relation to livestock farming is higher for the livestock farming system study site. It has been estimated that about 10 per cent of the total animal feed comes from the forestry and pastureland sector in the Naubise area, whereas the figures for Dhuskun and Yelung sites are about 30 per cent and 90 per cent respectively (Table 4.12).

For its indemnification, livestock provides manure to the forestry and pastureland to some extent. Animals during grazing are calculated to leave about 800 kg of fresh dung at the Dhuskun site, about 500 kg at Naubise, and over 1,600 kg at the Yelung site.

Linkages with Farm Households

Farm households are deriving various farm outputs from different components of the farming system with their labour inputs and management skills.

Farm households have produced some cereals, oilseeds (mainly mustard), potatoes, and cash crops, including fruits and vegetables, at least for home consumption. Farmers in some mountain areas also seem to have disposed their limited farm outputs for cash income which is expended in meeting demands for other necessary commodities. Out of the total cereal grain production, from less than a hectare of land (0.97 ha), an average farm household in Naubise is estimated to consume 1,662 kg of cereals, 80 kg of potatoes, and fruits and vegetables to the tune of 291 kg and 150 kg respectively. Similarly, households with a family size of 7.13 are estimated to consume 335 litres of milk in the form of fluid milk, ghee, butter, and curd and to use 2,091 kg of fuelwood annually.

The average per capita/annum fuelwood consumption is estimated to be about 298 kg in Naubise, 521 kg in Dhuskun, and 552 kg in Yelung. Crop by-products and farm trees meet almost all the demand for fuelwood in Naubise. Whereas in Dhuskun and Yelung, the forests are the main suppliers of fuelwood. The quantity of crop by-products used as fuel is as high as 708 kg per household in Naubise compared to 72 kg and 16 kg in Dhuskun and Yelung respectively. Farmers, particularly in accessible areas (e.g., accessible by road or market), also use kerosene mainly for lighting purposes. The annual kerosene consumption rate was not recorded in any of the study areas, nevertheless the reason behind the lowest per capita fuelwood consumption in Naubise is the higher rate of kerosene used.

The per capita fuelwood consumption is higher in Dhuskun compared to Naubise and Yelung. Farmers use fuelwood for many purposes (e.g., cooking, lighting, and even heating) in Yelung because of the cold climate. Fuelwood for heating is required in the other two study areas for shorter time periods only during winters. Moreover, people's food habits also guide the fuelwood requirement. For instance, people in Yelung brew beer and alcohol and this is one other reason why the per capita fuelwood consumption is higher there.

Linkages with the Market

The integration of farm activities with the market is increasing over time, although the scale of integration not only differs with the type of activity but also with the specific areas, depending upon accessibility and inaccessibility. Because of the strong market forces in Naubise, diversification and intensive crop cultivation have become possible. As a result, both the productivity and the total production of cereals as well as horticultural crops (newly introduced and diversified crops) have increased despite the fact that the compost and manure availability per hectare of cropped area is low compared to other study areas. Due to the presence of relatively good market infrastructure, the farmers at Naubise do not face the problem of selling their products nor the difficulty in obtaining agricultural inputs, which include chemical fertilizers, improved seeds, pesticides, and fruits and vegetable seedlings and saplings.(Tables 5.1, 5.2, and 5.3). This situation (particularly the case of chemical fertilizer availability) has released the forests from great pressure for compost materials. Similarly, farmers adopted increased stall-feeding practices realising that there is good market potential for milk and its products. This is exhibited by the increasing trend of replacing cattle with better quality buffaloes and the consequently higher amount of milk sold at Naubise (720 litres) compared to Yelung (about 420 litres) and Dhuskun (no sale at all). Higher agricultural production potentials and their linkages with the market at Naubise are also due to relatively larger farm sizes (Table 4.3) and better irrigation facilities (Table 4.5) compared to the other two study areas.

Market integration is weakest in the Dhuskun area. This is probably one of the reasons why the farming system in this area is more critical in terms of low or declining productivity; neither is the market able to supply chemical fertilizer to supplement and redeem the increasing loss of compost materials from forests nor are the farmers able to diversify their crop production to generate income as in Naubise.

In the case of Yelung, the livestock component of the farming system seems to be closely linked with the marketing system of the area. The marketing of milk products is linked with the Dairy Development Corporation (DDC) which purchases milk from farmers through the Cherdung Cheese Factory established in Jiri and its sub-branches located in Yelung area. This factory provides some necessary inputs in terms of veterinary services, and assists farmers to obtain credit.

While the farm households are almost solely dependent upon markets for consumer goods and services at all study sites, the market's role as supplier of food (e.g., cereal grains) is most pronounced in Yelung where about 40 per cent of the total household annual food consumption is obtained from the market.

Implications of the Linkages

As discussed earlier, various outputs have been generated as a result of the integration of different components of the farming system. Some of the outputs obtained from one component have been used in other components in the form of inputs for deriving outputs from the latter and vice-versa. This section will throw some light on the implications of the linkages in terms of nutrition, employment, and income.

Nutrition

The nutrition status of the people has been assessed in terms of calorie intake. The per day, per capita calorie intake rates are estimated at 2,012, 1,748, and 1,326 for Naubise (horticultural crop-based farming system), Dhuskun (cereal crop-based farming system), and Yelung (livestock-based farming system) respectively (Table 5.4). Food crops (mainly cereals) predominate over all other sources (e.g., fruit and vegetables, livestock) of calorie supply in all study sites and their share ranges from about 90 per cent (in Naubise) to 99 per cent (in Dhuskun) of the total calorie intake (Annex 7) Livestock-based food products appear to be the second major source and their share in the total calorie intake ranges from one per cent in Dhuskun to a little over eight per cent in Yelung. The contribution of fruit and vegetables is virtually nil except in Naubise where the figure is estimated at 3.8 per cent.

Table 5.4: Calorie Intake Per Capita Per Day by Source and Study Site

	Dhuskun		Naubise		Yelung	
	Calorie	%	Calorie	%	Calorie	%
Food Crops (Cereals mainly)	1733	99.0	1804	89.7	1221	92.0
Fruit and Vegetables	-	-	77	3.8	1	0.0
Animal Food	15	1.0	131	6.5	104	8.0
Total	1748	100.0	2012	100.0	1326	100.0

Source : Household Survey, APROSC 1989.

Income

Cash Income. The sale of agricultural and livestock products is the immediate source of cash income for farm households in all study areas. However, the contribution to the total cash income from various components or activities of a farming system vary from one area to another. In Naubise, for example, horticultural crops on an average constitute about 80 per cent, whereas cereal crops and livestock each contribute about 10 per cent to the annual farm cash income (Rs 21,460). The share of cereal crops and livestock in the total cash income in Dhuskun is about 53 and 47 per cent and in Yelung about 2 per cent and 98 per cent respectively (see Annex 4, Table 1).

Income generated from off-farm employment is very important in all study areas, particularly in Dhuskun, where most of the cash income comes from 'sideline' activities (96% of the total income). Based on field data, it is estimated that an average farm household derives a total annual cash income to the tune of Rs 39,166, Rs 4,028, and Rs 15,302 in Naubise, Dhuskun, and Yelung respectively (Annex 4, Table 2).

Gross Income. The quantification of the components of mountain farming systems is one of the vital issues that this study attempts to deal with. In this context, we know that, as expected, if fruit and vegetable production dominated the farming systems in Naubise then cereal crops in Dhuskun and livestock in Yelung, based on income generated by cash components of the system. However, our job may not be complete unless we also quantify the contribution of forests which are a vital component of the mountain farming system. In addition, cash income alone cannot fully and properly appreciate the linkages among the components of the system, and this is revealed in subsequent discussions. In response to this issue, a gross income analysis is made and discussed below.

Table 5.5 depicts that the estimated total annual gross income per average household is highest (Rs 52,022) in Naubise or the horticultural crop-dominated farming system area. This is mainly because of the income generated through the sales of fruits and vegetables (over 40 % of the total income). The figures for Yelung and Dhuskun areas respectively are computed at about Rs 19,000 and Rs 13,000. Based on this gross income analysis, if the cereal crop component claims the highest share (41%) of the total income for the cereal crop-dominated farming system (Dhuskun area) then livestock (55%) does so for the livestock-dominated farming system.

Table 5.5: Total Annual Gross Income Per Household by Source and Study Site

Income in Rs
Proportion in %

Farming System	Dhuskun		Naubise		Yelung	
Components	Rs	%	Rs	%	Rs	%
Cereal Crops	5226	41.0	15439	29.7	3227	17.1
Horticultural Crops	-	-	20925	40.3	-	-
Livestock	4515	35.4	14068	27.0	10395	55.0
Forestry/Pastureland	3016	23.6	1550	3.0	5272	27.9
Total	12757	100.0	52022	100.0	18894	100.0

Source : Household Survey, APROSC 1989.

Table 5.5 also indicates that all the three different types of farming system are basically crop - livestock - forestry integrated systems, although the forestry sector is loosely linked in the case of Naubise. This can be attributed to the strong market integration of the farming system. The highest (28%) contribution from the forestry sector is in Yelung. This is one of the main reasons why the livestock sector is performing so well in Yelung and it dominates the overall components of the system.

It should be recognised that all components (e.g., crop, horticulture, and livestock), apart from forestry, are substantively contributing to the farming system in Naubise and that the gross incomes* generated from each component are higher than those for the other two sites. This can be attributed not only to larger farm sizes (average farm size is 0.97 ha) with a greater proportion of irrigated land (Table 4.5) but also to greater accessibility to modern technology (e.g., HYVs, improved animals), along with agricultural inputs (e.g., seeds, fertilizers, pesticides, credit, etc), and a wider market (Kathmandu Valley).

Employment

The matrices (Tables 5.1, 5.2, and 5.3) indicate that farm activities are the major source of employment in all study sites. They provide 82 per cent, 68 per cent, and 87 per cent of the total employment days of 520, 724, and 969 per average farm household in Dhuskun, Naubise, and Yelung respectively. The rest is provided by off-farm activities which include services, business, construction, portering, etc. Within the farm, crops (e.g., cereals) contribute about 40 per cent of the total employment generated in Dhuskun, horticulture combined with cereal crops contribute about 55 per cent in Naubise, and livestock provides over 90 per cent in Yelung. The matrices also indicate that livestock has remained one of the vital components of the mountain farming system as far as employment generation is concerned. It has generated about 45 per cent in Naubise, 60 per cent in Dhuskun, and is overwhelmingly predominant in Yelung.

The employment opportunities provided by the market are highest in Naubise, followed by Yelung and Dhuskun. The per household average number of mandays employed annually in off-farm activities ranges from 94 in Dhuskun to 230 in Naubise. Construction work (e.g., Lomosangu-Bahrabise road) and business are the two major 'sideline' activities in Dhuskun; the former is the major contributor to employment and the latter to income. Compared to other study areas, these two off-farm activities in Dhuskun appear to be temporary and unpredictable since the road construction is now over and the income generated through business** largely depends on the attitude of the customs' people stationed at the Nepal-Tibet border. Tourism appears to be one of the major 'sideline' activities, particularly in Yelung which lies on the trekking route (Junbesi, Lukla, Namche Bazar) to Mt. Everest starting from Jiri. Many people in the area work as porters and trekking guides for tourists.

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* While computing **gross income**, all the commodities (e.g., both main as well by-products) produced by each component (e.g., cereals, horticultural crops, livestock, and forestry) of the farming system have been converted into their value terms by multiplying the total amount of produce with their respective prices. The opportunity costs of the family labour for each farming system are considered as **proxy** for non-tradable commodities (e.g., fodders, compost, and bedding materials).

** As per the agreement between the Government of Nepal and Tibetan Autonomous Region of the People's Republic of China, Nepalese people residing within a periphery of 26 km of the Nepal-Tibet border, which encompasses the Dhuskun area, are entitled to import a few items of basic necessities (e.g., food items, shoes, umbrellas, a few metres of cloth,) from Khasa in Tibet to Nepal without any customs and duties. However, it is interesting to observe that people, particularly during the winter or off-season, when agricultural activities are few import these items very frequently; some people ferry almost every day. They sell these items in the local markets (e.g., Lamosangu, Bahrabise) and make an attractive income.

Remarks

1. The above-discussed matrices (Tables 5.1, 5.2, 5.3) depict the direction and magnitude of the input and output flow from the production (those major activities or components which produce outputs in terms of volume or value terms; e.g., crops, livestock commodities, etc) to the consumption (those components which consume the inputs on outputs) sector of three different types of farming systems, for example, cereal crop-dominated (Table 5.1), horticultural crop-dominated (Table 5.2), and livestock-dominated (Table 5.3).

2. The input and output flow shown in the matrices are indicative of one complete year in an average farm household for each type of farming system as discussed in (1).

3. The figures in parentheses are the total amounts of output in terms of volume or value produced/consumed by the production/consumption sectors.

4. Cereals, which include paddy, maize, wheat, millet, barley, and buckwheat, are being used for home consumption in terms of food, concentrates for animal feed, seeds for crop cultivation, for rental payments to landlords, and wage payments to hired labour in kind.

5. The figures that are shown under the market column are from the sale of commodities, cash expended in markets for buying household necessities, etc.

Footnotes

1. Payment of rent to landlords from tenant farmers.

2. Payment in kind to hired labour.

3. Crop residues are also being used as fuel; this situation arises when the supply of fuelwood is scarce.

4. The indicated amount of animal feed in terms of TDN is estimated to be consumed by animals in the form of green grass and fodder during grazing in forests, on pasturelands, and along river banks. The total number of hours spent per year in grazing is also given in the tables.

5. Includes all cash expenses incurred in purchasing various household and other commodities and items.

6. The total number of mandays involved in off-farm activities.

6

FARMERS' STRATEGIES AND THEIR SUSTAINABILITY IMPLICATIONS TO MOUNTAIN AGRICULTURE

Historically, people in the mountains have been found to have generated capabilities to tame the mountain environment which is harsh, rough, and fragile in order to derive outputs for satisfying their needs. In this respect, farmers appear to have adopted a number of strategies, either in terms of modifying the characteristics of the mountain environment itself or in the form of modifying their operational measures to converge with the mountain characteristics (e.g., inaccessibility, fragility, marginality, diversity, niche, and human adaptation) so that their readymade or anticipated operational measures match and facilitate the generation of outputs. Hence, the implications of these strategies to the sustainability/unsustainability of mountain farming systems will be discussed in this chapter. Perhaps it may be useful to begin with a prelude on sustainability issues before we discuss different sections under this broad chapter.

Sustainability Issues

Despite its widespread recognition, sustainability is still a debatable issue that has been going on for the last few years. Commissions have been formed at the global level in order to investigate into sustainable development. The Brundtland Commission, for instance, attempted to examine the reasons causing environmental degradation and to identify potential relevant options to reverse the situation and bring about sustainable development.

In this paper the sustainability issues have been adapted from Jodha (1989b).

Conceptually speaking, the focus of 'sustainability' is on the issues of inter-generational equity. This implies equal (or greater) availability of options, in terms of human well-being or production prospects, to future generations as compared to the present one. Theoretical possibilities of such prospects, ensurable through the accumulation of capital stock and technology for use by future generations, are constrained by the capabilities of the biophysical resource base. The latter cannot be stretched or manipulated indefinitely, without initiating processes of irreversible damage. This indicates the primacy of biophysical resources in sustainable development. This is more so in the case of agriculture, the dependence of which on biophysical variables is more direct and crucial.

'Sustainability' is the ability of a system (e.g., the fragile resource-agriculture) to maintain a certain well-defined level of performance (output) over time, and, if required, to enhance the same, including through linkages with other systems, without damaging what Tisdell (1987) calls the essential ecological integrity of the system (Jodha 1989b).

Farmers' Strategies

Based on observations, speculations, and detailed interviews and discussions with concerned and local people, several operational measures that the farmers have been adopting in response to mountain characteristics and the public interventions made by the Government are identified. These measures are then categorised under a set of nine major strategies that are discussed sequentially. Attempts have also been made to examine the feasibility of each strategy in the context of the changing demographic pressures, markets, and various institutional and technological changes.

Extensive Cultivation Practices

This strategy refers to the cultivation of larger areas with less intensity of input (e.g. labour) use per unit of land. It generally indicates monocropping. Under this broad strategy, farmers have adopted various operational measures and the "slash and burn" cultivation practice is one of them (Table 6.1).

"Slash and Burn" Cultivation. This practice is widely known as shifting cultivation. In this system, farmers clear forests, bushes, shrublands, and any unwanted plants and set them on fire. Then potatoes, or potatoes with wheat or buckwheat, are sown on that piece of acquired land which is fit for cultivation without the application of any organic or inorganic fertilizers. This system is locally known as the "*Bukma* System" in the Yelung area. The piece of land is then left without cultivation for a considerable time period (3-5 years), once the first crops are harvested (Table 6.1). This cultivation practice contains a very important element of the sustainability of the farming system, because this practice has the merit of maintaining soil fertility naturally, i.e., without any external input or application of fertilizer or manure. This system is widely practised, particularly in the Yelung study area. The farmers are fully aware of the merits of the practice. The system or practice not only uses local inputs but also low inputs (e.g., seed, manure, labour, etc) per unit of cropped area. For details regarding the *Bukma* system, see Annex 9.

This practice is now under stress due to the population pressure. The time interval between one cultivation period to another on the same piece of land has been shortened from 3 to 4 years now, compared to 6-8 years about two decades ago. Another reason is people's fear that the Government may control and take the ownership of land if it is not cultivated more frequently. People are of the view that this might happen in the very near future once a cadastral survey takes place in the area. Hitherto, farmers did not have any legal ownership rights over the land except some receipts for land taxes paid to a government-appointed local leader or person in the village.

Remarks. The historical background of this "slash and burn" cultivation practice, particularly in the Naubise study area which is accessible and is an area newly transformed through the use of improved agricultural technologies, was not available, apart from some anecdotes. Some fading memories about the system were forthcoming in Dhuskun area. Particularly in the mountain areas, the extensive land cultivation strategy can be appreciated from the sustainability point of view. This is because the mountains are inaccessible (both in physical and socioeconomic dimensions), fragile, etc. This option is feasible when there is less pressure on land. Increased demographic pressure alone makes this strategy unfeasible for future generations.

Intensive Cultivation Practices

This strategy relates to the practice that encourages higher use intensity of agricultural inputs per unit of land. Multiple cropping or higher cropping intensity are the major indicators of this practice (Table 6.1).

The practice of intensive cultivation began because of increased population pressure and the availability of new technologies (e.g., HYVs, fertilizers, pesticides, etc). Cultivation of more than one crop per year, even on lowlands that used to be fallow after harvesting the first crop, is becoming the general practice even in relatively inaccessible areas of the mountains, e.g., Dhuskun where farmers are growing maize after paddy. This is a recent trend in the area. In the case of Yelung, although the area under lowlands is minimal, the land is still kept fallow after paddy and is used for grazing animals.

Table 6.1: Farmers' Strategies and Their Operational Measures

Operational Measures of the Strategies	FARMERS' STRATEGIES								
	Extensive Cultivation Practice	Intensive Cultivation Practice	Extensive Management Practice	Intensive Management Practice	Backward and Forward Linkages	Group Efforts	Risk Hedging	Biomass Utilisation	Diversification
1. Farmland									
i. "Slash and Burn" cultivation practices e.g. *"Bukma System"*	*							*	
ii. Existence of abandoned land	*		*		*		*		
iii. Multiple cropping practices		*			*		*		*
iv. Cultivation of local cultivars (with varieties lower but guaranteed yield and resilence to moisture stress and diseases)					*		*	*	
v. Usage of high stalk : grain ratio and salvage potential crops		*		*	*		*	*	*
vi. Higher seed rate application, particularly for maize							*	*	
vii. Trend of fodder tree plantation on private land				*	*			*	
viii. Terrace making or contour farming practices		*		*					
ix. Cultivation of improved cultivars of cereals and horticultural crops		*							*
2. Livestock									
i. Livestock keeping with different combinations of animals				*			*	*	*
ii. Preference for sturdy animals having multiple socioeconomic values					*		*	*	
iii. Preference for low-cost animals with short gestation periods			*	*			*		
iv. Sharing of livestock keeping (steadily emerging)			*		*	*		*	
v. Mobile herd keeping (transhumance)			*	*	*			*	

Contd....

Table 6.1: Farmers' Strategies and Their Operational Measures

(Continued)

Operational Measures of the Strategies	FARMERS' STRATEGIES								
	Extensive Cultivation Practice	Intensive Cultivation Practice	Extensive Management Practice	Intensive Management Practice	Backward and Forward Linkages	Group Efforts	Risk Hedging	Bio-mass Utilisation	Diversification
3. Forest/Pastureland Grazing Land									
i. Preference for extracting fodder, fuelwood, timber, and other biomass and other by-products from the forest even if they are available on private land			*				*	*	
ii. Natural resource management at community level						*	*		
4. Crop-livestock Integrated Farming				*	*		*	*	*
5. Self-help Activities									
i. Sharing of individual assets for usage :									
- use of bullock power			*	*		*	*		
- use of other farm implements			*			*			
ii. Exchange of labour, particularly during peak season, otherwise agricultural farming could seriously be menaced			*	*		*			
iii. Installation of indigenous water mills for grinding cereals at community level						*			
iv. Development of small irrigation schemes under farmers' management									
6. Miscellaneous									
i. Adoption of different 'sideline' activities							*		*

Note: * indicates the presence of an operational measure of the farmers' strategy.

The level of land use intensity appears to be higher in Dhuskun and Naubise areas where the cropping intensities are calculated at 172 and 165 per cent respectively. Population pressure is the biggest single factor for inducing higher cropping intensity in Dhuskun, where the population density per hectare of cultivated land is just over nine persons. The figure for the same in Naubise is over seven persons. Due to climatological factors and the unavailability of suitable technologies, the cropping intensity in Yelung appears to be very low (115%), despite the fact that the population density per hectare of cultivated land is extremely high (20 persons). This is the reason why the people in the area have to depend heavily upon foodgrain supplies from outside. About 40 per cent of the total nutrition supply comes from outside the farm (Annex 7). People purchase foodgrains from dealers or from branch offices of the Nepal Food Corporation located at Jiri.

Remarks. Intensive cultivation practices imply frequent disturbance of the soil, resulting in loose soil and thus stimulating erodability. This situation makes the land fragile. However, there are some operational measures that can improve the fragile resource base by undertaking soil conservation strategies through an emphasis on biomass production (e.g, fodder, fuelwood tree plantation on private/public land, terrace farming, etc). The intensive cultivation strategy seems to be a feasible option for the future, particularly in areas that are accessible and have relatively less steep slopes (e.g., Naubise) and which can depend on some outside inputs (e.g, seeds, fertilizer, etc). With efforts for more biomass production (e.g., fodder and bedding materials for animals and compost for manuring), the intensive land cultivation strategy will not be a less viable option even for the Dhuskun and Yelung areas.

Extensive Management Practice

This management practice relates to the labour use pattern. If the highest intensity of labour use per unit of land refers to intensive management practice then the lower intensity indicates extensive management practice.

The extensive/intensive cultivation and management strategies or practices appear to be synonymous and seem to be mutually inclusive, however they are not so in reality because one can observe intensive management practice in an extensive cultivation setting and vice versa. For example, the farmers in Yelung employ the highest labour intensity which is computed at about 205 mandays per hectare of crop cultivation for extensive cultivation practices compared to the 173 and 169 mandays in the case of Dhuskun and Naubise respectively, where intensive cultivation practices are common.

There are not many examples or operational measures that farmers are employing under this extensive management strategy. However, sharing of livestock-keeping (among neighbours, relatives, friends, or those who trust each other), mobile herd keeping, and the "*bukma* system" can be considered to be some of the measures (Table 6.1).

Remarks. In general, the extensive management strategy that bears some elements of sustainability, particularly from the premise of low input use practice, cannot be considered a viable strategy anymore in the context of the increased demand for farm produce. This remark is most applicable in case of the *bukma* system. The sharing of livestock keeping has some positive aspects because this sharing practice, in general, implies shifting animals from low to high fodder resource bases. Similarly, the transhumance livestock management system (e.g., mobile herd-keeping) inherits the merits of lowland-upland linkages, in which case both areas avail themselves of outputs/commodities for consumption that are otherwise not available in either of the areas. However, these operational measures are becoming increasingly less feasible due to intensive cultivation practices, particularly in lowland areas. This implies scarcity of fallow land which otherwise usually attracts mobile herds (e.g., sheep, goat, *chauri*) from the high mountains (upland) to the low mountains (lowland) in search for compensation during times of feed shortage during the winter season. This is the reason why this traditional practice is slowly disappearing.

Intensive Management Practices

As referred to in the extensive management strategy this practice basically relates to the high intensity of labour use per unit of land or cropped area.

Under this strategy, farmers are resorting to a number of operational measures, e.g., multiple cropping, terrace farming, cultivation of improved cultivars, livestock-keeping with different combinations of animals, etc (Table 6.1). Because of technological innovations and their availability, farmers have recently started to resort to labour intensive farming by superseding millet with the upland rice variety - CH 45. Vegetable farming, again a labour intensive farming system, is slowly replacing cereals, particularly in the Naubise area. Similarly, stall-feeding practices in the case of livestock farming are becoming increasingly acceptable to farmers, particularly in the Naubise and Dhuskun areas where there is demand for more labour per unit of livestock. Also, the high intensity of labour use associated with the practice is attributed to reduction in the size of livestock holdings. This operational measure particularly stipulates the long-term sustainability implications because this type of livestock management practice has already brought some positive changes by encouraging the maintenance of smaller but qualitative units of livestock. Therefore, based on the information from the field survey, the size of livestock holdings is declining over time while the proportion of improved animals is increasing.

Terrace farming, which is a traditional practice (labour intensive farm management), bears a great sustainability implication for mountain farming systems by preventing soil erosion. Similarly, fodder/fuelwood tree plantation on the bunds and ridges of cultivated land is not a recent version of farm management practice, nevertheless the intensity of plantation and the maintenance of trees have been intensified, particularly in the Naubise and Dhuskun areas.

However, the situation in the high mountains is different because extensive management strategies are being practised. Stall-feeding practices are non-existent where open grazing systems still exist in large areas under alpine pastureland and meadows. People's dependency on forests/pastureland for fodder, fuelwood, and other compost materials is very high (see Tables 5.1, 5.2, and 5.3).

Remarks. In general, the intensive management strategy can be a feasible option in order to reverse the unsustainable farming system to a sustainable one, although the strategy may require high use intensity of the resource base. There is nothing wrong in doing so if the enhancement and maintenance of the regeneration capacity of the resource base is taken care of. The existing situation in Yelung, in terms of a relatively high level of resource endowment, associated with extensive resource management practice will not remain for long. The situation between now and even ten years earlier has already undergone conspicuous changes in terms of increased time allocation to fetch forest and natural resource products, including several other parameters. Therefore, the present changing picture of the whole farming system, within a time period of 20-40 years, clearly communicates the message that an intensive management strategy, against the backdrop of a changing environment, will be a necessary precondition for maintaining mountain agriculture in a sustainable manner in all the areas of the region, (e.g., population pressure, technological innovation, etc).

Backward and Forward Linkages

This terminology refers to a situation in which the 'give' and 'take' from one activity to another or from one component to another of a farming system exists. The presence of strong backward and forward linkages within a system helps reduce outside dependency, thereby facilitating smooth functioning of the system which is the essence of sustainability.

Farmers in the mountains are well conversant with the merits of this strategy and are excersising it by undertaking various operational measures, e.g., presence of abandoned land, higher seeding rates, and multiple cropping (Table 6.1). Farmers in the region have been maintaining an integrated (crop-livestock-forestry) farming system for centuries, although the third component is the latest inclusion (in terms of realisation) in the system. This is mainly guided by the strategy of backward and forward linkages. Despite the higher yield potentials of improved crops, farmers have not completely renounced the cultivation of local cultivars which normally destroy the strains having a high stalk: grain ratio even in more accessible and relatively new technologically influenced mountain areas like Naubise. This is because they also need fodder for livestock, compost for manuring, and roofing materials to protect houses and cattle sheds from rain and sun and these are available from crops. Farmers appear to have selected and cultivated even improved crops by employing this strategy. This is corroborated by discoveries in the Naubise study site. It has been already recognised that the area enjoys the highest level of technological innovations in agriculture (in terms of improved crop cultivation and management practices). Along with highest yields in main crop products, the yields of crop by-products (e.g., dry fodder, compost, bedding, and roofing materials) per hectare of cropped area are also the highest (2,620 kg) in the Naubise area followed by Dhuskun (2,130 kg) and Yelung (1,785 kg). The Yelung site is virtually unexposed to new agricultural technologies. For example, the area under improved crops and the use of chemical fertilizers are either extremely low or non-existent in both the Dhuskun and Naubise sites (Annex 3, Tables 4 and 6).

Remarks. This strategy is, however, also losing its grip, primarily due to exogenous factors. Good data on resource management and extraction rates are not available. However, observations showed that the strong and tight linkages between and among different components of the farming system that existed in the past are now breaking down. For instance, the per unit fodder supply to livestock and compost materials to crops which come from the forests/pastureland have been decreasing and the resulting reduced supply of manure from livestock to crops has led to reduced levels of foodgrain and livestock production. Since again there is limited scope for supply of inputs from outside the farm due to mountain characteristics, this strategy of backward and forward linkages will be an equally important and viable option even for the future in order to strengthen the capability of the system to sustain itself.

Group Efforts

Any activity undertaken on a communal basis to achieve or fulfill a well-defined objective comes under this strategy of group efforts. The essence of the strategy is that it increases the individual capacity to absorb shock arising from natural calamities, e.g., sharing of foodgrain/livestock during drought, flood, etc. Exchange of labour during peak season and the sharing of farm implements are other examples of group efforts (Table 6.1) that enable one to perform many beneficial activities. This strategy in the past enhanced the sustainability of the system. However this option is now overstrained, primarily due to public intervention.

Let's take the example of the nationalisation of the forest resource base in Nepal which took place in the 1950s. This policy completely disregarded the positive attributes made by the community management system which had greatly enhanced sustainable production and the use of all common property resources (e.g., land, water, etc). The ultimate consequences are deforestation and overgrazing, resulting in serious depletion of the natural resource base and threatening the whole mountain community. The recent change in the policy to safeguard the rights of the community on the forest resource base for its conservation and development is the outcome of full realisation of the disregard of the group effort strategy. Thus, some positive outcomes have already surfaced in all three study areas. Degraded forests in Naubise and Dhuskun and alpine pastureland and meadows in Yelung are now being improved through community management practices and are responsible for the protection, conservation, and utilisation of the produce (e.g., fodder, fuelwood, compost materials). Only two years back, a management committee for alpine

pastureland was formed in Yelung. This five member committee, consisting of local people, with the addition of one technical advisor who is from the cheese factory owned by the Dairy Development Corporation, is stressing the implementation of controlled grazing of animals in rotation rather than haphazardly.

Similarly, the degraded forests in Naubise have been reforested and afforested and the people are allowed only 2 out of 50 ha of forest for free/regulated animal grazing. The rest of the forest is completely controlled and the people are allowed only to'cut and carry' green fodder, compost, and bedding materials. Similar situations prevail in the other areas too.

Remarks. This traditional resource management practice must be strengthened in order to make mountain farming systems sustainable even in the future, be it in the field of forests/pasturelands or water. The recent trend of reinstalling farmer-managed irrigation schemes and water mills for grinding cereals are the outcome of the revitalisation of this group effort strategy. The *ghatta* or water mills, which were operated individually, are also now run on a community management basis. More and more *ghatta* (from five it has increased to nine) are being installed by farmer groups. The practicality and usefulness of this strategy still do exist and will be applicable even in the future.

Risk Hedging

Any activity undertaken on an individual or group/community basis with the aim of protecting it from any risk is termed as risk hedging. The main objective of this strategy is to maximise benefit (e.g., in value or volume of produces) while minimising risk.

One of the basic features of traditional farm management practices is to undertake activities associated with a minimum level of risk. Farmers have always, for instance, preferred local cultivars because of this attribute (e.g., there will be a small reduction in crop yields even during odd periods, viz., drought, hailstorm, insects and disease infection). Use of more seeds is again to hedge the risk arising from moisture stress. Preference for small ruminants over large ones is also guided by this strategy. This is particularly so in the case of small, marginal landholders who cannot take the high risk associated with having large animals, the loss/death of which could mean disaster to them. Investment in large ruminants could be equivalent to the value of the total assets a marginal or a landless farmer may hold (Table 6.1). For some more details see Annex 8.

Biomass Production and Use

This strategy refers to an activity or enterprise, that, when undertaken, helps to increase biomass (e.g., fodder or other vegetation for compost, bedding materials) production.

Farmers have adopted various operational measures under this strategy. Some land, particularly in Yelung was abandoned, not only because of uneconomical cultivation in terms of low yields of foodgrain but also to allow the vegetation to regenerate which could be used as fodder/bedding materials. Use of more maize seeds is also guided by this strategy so that increased green fodder enhances the productivity of animals, otherwise the emphasis on the usage of high stalk: grain ratio crops would never have been appreciated. Perhaps the strategy of biomass production and use which is associated with traditional farming practices is one of the most important elements in the sustainability of a system. Some operational measures adopted by the farmers under this strategy are presented in Annex 8.

Remarks. This strategy can also be appreciated in the context of mountain characteristics, such as inaccessibility and fragility, since the compost materials and manure are the only sources for fertilizing land and the vegetative cover improves the fragile environment. Therefore, their option is still feasible

and will be effective even in the future for sustainable development of mountain agriculture, particularly in the remote and inaccessible areas.

Diversification

Diversification of farming relates to the practice of growing various kinds of cereal, fruit, and vegetable crops and maintaining different types of animals on the farm.

The Government is giving new impetus to diversifying crop husbandry in agricultural development. This policy has helped farmers in Naubise to diversify their farm activities by cultivating not only new varieties of cereal crops but also fruits and vegetables, thereby rising above the subsistence level of production; some of the farmers are making gross incomes of hundreds of thousands of rupees from such diversifications particularly from vegetable farming on a commercial scale on about a hectare of land. Multiple cropping and crop - livestock integrated farming are also examples of farm diversification.

Remarks. Mountain regions, as such, are typified by diversity in terms of their topography, altitude, slope, and aspect, resulting in a large variation in microclimates which ultimately provides the opportunities for undertaking diverse activities in order to exploit the 'niche' of the mountains. This implies that there is comparative advantage in exploiting this diversity. Therefore, the strategy of diversification should be given invariable impetus even in public interventions in future because diversity will prevail forever and so will the variation in microclimates in the mountains.

The Sustainability Implications of Mountain Agriculture

Attempts have been made to assess mountain agriculture in the context of its sustainability/ unsustainability by studying three different types of mountain farming system. As discussed earlier, they are crop-dominated, horticultural crop-dominated, and livestock-dominated farming systems located in Dhuskun, Naubise, and Yelung respectively (Table 2.1). To this effect, both the positive (+) and negative (-) changes in resource characteristics, production flow, and the utilisation/management of farming systems which have been conceptually considered as the three most important elements/components of a sustainability matrix (Chapter 2), were recorded and documented based on extensive and comprehensive discussions with farmers, local leaders, key informants, and the study team's observations. Some of the changes are easily perceivable while others are in disguised forms.

These over time positive/negative changes, considered as indicators of sustainability/unsustainability of mountain farming systems, are shown in Tables 6.2, 6.3, and 6.4. Here readers are cautioned that any positive or negative change that relates to the sustainability or unsustainability of a farming system are, in general, location-specific. These over time changes refer to the changes that have taken place during the last thirty years or so.

Basically, these changes are the outcome of the strategies adopted by farmers while responding to the endogenous and exogenous factors of a mountain farming system (Fig. 1), keeping in mind the mountain characteristics as they are perceived. The positive changes can be considered to occur when convergence between the attributes of strategies and mountain specificities takes place and vice-versa.

Table 6.2: Over Time Changes as Indicators Leading to Unsustainability/Sustainability of Mountain Agriculture (Crop - dominated Farming System in Dhuskun)

	Level of Visibility			
	Directly Visible Changes	Sign of Changes	Indirectly Visible Changes	Sign of changes
I. RESOURCE BASE	- Increased literacy rate	(+)	- Increased distance to parcel	(-)
	- Abandonment of land due to landslides	(-)	- Increased fragmentation of land	(-)
	- Abandonment of land due to low fertility	(-)		
	- Decreased area under forest pastureland	(-)	- Reduced size of parcel	(-)
	- Emergence of stones/rocks on cultivated land	(-)		
	- Increased size of farm through conversion of arable land	(-)		
	- Increased size of farm through conversion of marginal land	(-)		
	- Decreased size of livestock holding, without adequate qualitative change	(-)		
	- Reduced diversity of natural vegetation, e.g., disappearance of fodder trees sp. from forests, grasses from pastureland, etc.	(-)		
II. PRODUCTION FLOW	- Declined level of cereal crop yields	(-)	- Increased collecting time of fodder, fuelwood, timber, from public or common land	(-)
	- Declined level of crop by-products	(-)		
	- Reduced quantity of compost, manure application rate per unit of cropped area	(-)		
	- Decreased level of fodder, biomass supply from private land	(-)	- Increased time allocation for water fetching	(-)
	- Decreased level of fodder, biomass supply from public land	(-)	- Reduced level of nutrition supply to human population	(-)
	- Declining trend of livestock productivity	(-)	- Increased intensity of foodgrain supply from outside the farm	(-)
			- Increased income from off-farm activities	(+)
			- Increased rate of out-migration, e.g., seasonal	(-)
III. UTILISATION/ MANAGEMENT PRACTICE	- Forest and other common property resources are under community's control (e.g., fencing forbidden) in order to improve the resource base	(+)	- Increased intensity of crop by-product use (e.g., maize cobs after threshing, wheat and barley straws, etc.) as firewood	(-)
	- Emergence of increased level of stall-feeding practice	(+)	- Utilisation of *'banmara'* plants as roofing materials for cowsheds due to shortage of *khar* - traditional plant material for roofing.	(-)
	- Increased expenses in other domestic unproductive activities from the income derived from agriculture and off-farm activities	(-)		
	- Increased cropping intensity	(+)		

Note: Negative sign of change (-) = Leading to unsustainability
Positive sign of change (+) = Leading to sustainability

1. There are several points/issues or indicators of change that fit into more than one column (directly/indirectly visible) of changes and categories of mountain agriculture (e.g. resource base, production flow, and utilisation/management practices).

2. These changes have been recorded and documented based on extensive and comprehensive discussions and interviews with local and informative persons. The over time changes refer to the changes that have taken place during last twenty/thirty years or so.

Table 6.3: Over Time Changes as Indicators Leading to Unsustainability/Sustainability of Mountain Agriculture (Horticultural Crop-dominated Farming System in Naubise)

	Level of Visibility			
	Directly Visible Changes	Sign of Changes	Indirectly Visible Changes	Sign of changes
I. RESOURCE BASE	i. Increased rate of literacy	(+)	i. Increased fragmentation of land	(-)
	ii. Increased level of stream or river bed	(-)	ii. Reduced size of parcel of land	(-)
	iii. Nearby forest and grazing land converted into cropland	(-)	iii. Increased distance to a parcel of land	(-)
	iv. Grazing land (in Jiwanpur) was completely converted into fruit and vegetable farms	(-)		
	v. Increased size of farm through the conversion of marginal land	(-)		
	vi. Cattle replaced by buffalo keeping	(+)		
	vii. Decreased size of livestock holding with qualitative change in herd structure	(+)		
	viii. Increased area under vegetable cultivation	(+)		
	ix. Increasing trend of fodder fuelwood tree plantation on private land	(+)		
	x. Reduced volume of water in *'kuwa'*(well)	(-)		
	xi. Accumulation of assets due to increased income from vegetable farming (e.g., purchasing of land; *'khar'* roofing materials replaced by tin, buying more buffaloes while replacing cattle etc.)	(+)		
II. PRODUCTION FLOW	i. Increased level of cereal crop yields	(+)	i. Increased collecting time for fuelwood from common land	(-)
	ii. Increased level of vegetable production	(+)	ii. Decreased time allocation in water fetching due to increase in rate of piped water supply	(+)
	iii. Increased quantity of crop by-products (e.g., straws)	(+)	iii. Increased level of nutrition for human population	(+)
	iv. Increased level of fodder/fuelwood supply from private land	(+)	iv. Increased level of off-farm income	(+)
	v. Decreased quantity of fodder and other biomass supply from public or common land	(-)		
	vi. Reduced level of compost and manure application rate per unit of land	(-)		
	vii. Augmented intensity of chemical fertilizer application rate	(+)/(-)		
	viii. Increased intensity of disease and pest infection	(-)		
III. UTILISATION/ MANAGEMENT PRACTICE	i. Nearby small patches of forests are under control by the comunity to improve the degraded resources	(+)	i. Emerging trend of renewing improved seeds	(+)
	ii. Increased cropping intensity	(+)		
	iii. Increased intensity of stall-feeding practices	(+)		
	iv. Increased intensity of water utilisation practice (e.g., winter irrigation for vegetable farming is the present trend)	(+)		
	v. Emergence of use of agro-chemicals for storing grains	(+)		
	vi. Emergence of practising improved methods of compost making (10% of the total household is practising the method)	(+)		

Note: Negative sign of change (-) = leading to unsustainability. Positive sign of change (+) = leading to sustainability

1. There are several points/issues or indicators of change that fit into more than one column (directly/indirectly visible) of changes and categories of mountain agriculture (e.g., resource base, production flow, and utilisation/management practice).

2. These changes have been recorded and documented based on extensive and comprehensive discussions and interviews with local and informative persons. The over time changes refer to the changes that have taken place over the last twenty/thirty years or so.

Table 6.4 Over Time Changes as Indicators Leading To Unsustainability/Sustainability of Mountain Agriculture (Livestock-dominated Farming System in Yelung)

	Level of Visibility			
	Directly Visible Changes	Sign of Changes	Indirectly Visible Changes	Sign of Changes
I. RESOURCE BASE	i. Increased literacy rate	(+)	i. Increased fragmentation of land	(-)
	ii. Increased trend of encroachment of forest pastureland for food production by converting them into cultivated land	(-)	ii. Reduced size of parcel of land	(-)
			iii. Increased distance to a parcel of land	(-)
	iii. Decreased trend of area under pastureland/meadows for grazing	(-)		
	iv. Reduced level of genetic diversity (e.g., some nutritious grasses in the pastureland are disappearing)	(-)		
	v. Abandonment of land due to low fertility, though on small and limited scale	(-)		
	vi. Decreased size of livestock holding without adequate qualitative change	(-)		
	vii. Decreased level of water in the streams of Yelung	(-)		
	viii. Emergence of sporadic over-grazing	(-)		
	ix. Change in herd structure by discarding goat together with *chauri* flock (perhaps it is an indicator of reduced level of biodiversity)	(-)		
II. PRODUCTION FLOW	i. Declining trend of crop yields	(-)	i. Increased collecting time for compost, fodder, and other biomass from forest/ pastureland	(-)
	ii. Fodder tree supply from common land slightly reduced	(-)		
	iii. Emergence of declining trend of compost and other biomass supply from common land	(-)	ii. Emergence of shifting labour use from livestock farming to foodgrain production	(-)
	iv. Increased demand for labour in foodgrain production without much increase	(-)	iii. Increased incomes from sideline activities	(+)
	v. No chemical fertilizer application	(+)		
	vi. Extensive use of local cultivars, even among the farmers who are practising improved cultivation to safeguard local resource-centred production patterns	(+)	iv. Increased foodgrain supply from outside (e.g., NFC, Jiri)	(-)
	vii. Exploiting local resources through quarrying	(+)		
	viii. Increasing (slightly) supply of milk from *chauri* due to DDC policy	(+)		
III. UTILISATION/ MANAGEMENT PRACTICE	i. Emergence of alpine pastureland/meadows under community management system	(+)	i. Still the majority of farmers (66%) harvest only the top portion (with grains) of the wheat stem while leaving the lower part for animal grazing	(+)
	ii. Increased use of water mills *('ghatta')* for grinding cereals releasing labour req. during peak period	(+)		
	iii. goats with *chauri* replaced by sole *chauri* keeping and thus reduced level of biodiversity	(-)	ii. Application of agro-chemicals (e.g., pesticides)	(+)
	iv. Open and haphazard grazing practice on pasturelands	(-)	iii. Increased rate of women's involvement in the decision-making process, particularly in *chauri* farming	(+)
	v. Compost making with pits during rainy season and without pits during winter season	(+)		

Note: Negative sign of change (-) = leading to unsustainability. Positive sign of change (+) = leading to sustainability

1. There are several points/issues or indicators of change that fit into more than one column (directly/indirectly visible) of changes and categories of mountain agriculture (e.g. resource base, production flow, and utilisation/management practice).

2. These changes have been recorded and documented based on extensive and comprehensive discussions and interviews with local and informative persons. The over time changes refer to the changes that have taken place over the last twenty/thirty years or so.

The Crop-dominated Farming System at Dhuskun

Based on the widespread negative changes, the crop-dominated farming system study area appears to be the most critical area. The production flow (extraction rate) has been seriously affected, because the crop yields and biomass supply from the land are declining critically, and also because the resource base (endowment) itself has been gravely damaged and requires a considerably long time period to regenerate even if effective measures are taken immediately to relieve the pressure on land. Unlike the Yelung site, there is no land (e.g., marginal, forest grazing land) left for further cultivation. In addition, the cropping intensity is also the highest (172 %) in the area and this indicates the limited scope for further intensification of agricultural production. In some areas, stones/rocks have begun to surface on cultivated land since the supply of compost materials from both private and public land and manure from livestock have been greatly reduced compared to twenty or thirty years ago. Because of this seriously depleted condition of natural resources, the limited available area under forest is strictly forbidden for use. It is now under the control of the Government. Unlike in the Naubise area, the fodder supply from private land is very low and has resulted in a reduced size of livestock holding and thereby a decreased level of manure; an essential for crop production. To compensate, there is an emerging trend of chemical fertilizer application (33 kg /household). But on the supply side, fertilizer has always remained problematic. Moreover, the effectiveness of the fertilizer will be encouraging only when irrigation facilities with improved seeds are available and these too are lacking in the area.

During the field survey, some farmers had also reported that the average application rate of compost and farm-yard manure had increased because of the increase in stall-feeding practices. However, the majority of farmers were of the view that, owing to multiple factors (e.g., decreased quantity and quality of forest/pastureland, reduced size of livestock holding and increased cropping pattern), the average application rate of organic manure per unit of cropped area had decreased by 30 per cent over a time period of about three decades or so.

People have expressed their concern about the likely reduction in off-farm income due to the completion of the Bahrabise portion of the Arniko highway which has been generated substantial employment opportunity since the last few years. Another major source of income is from business. Therefore, the contribution of off-farm income to the total cash income is the highest (95 %), although the total amount is the lowest in this area compared to other study areas (Annex 4, Table 2).

Apparently, it appears that ethno-engineering seems to be in a more developed form in the Dhuskun area where stable terrace farming is very prominent. Some farmers have also cultivated land in different locations at varying altitudes (1,000 m to 3,000 m), giving an indication of the diverse nature of the farming system*. This also indicates the presence of intensive cultivation in the area, however it is with a low intensity of inputs. The average FYM/compost application rate per unit of cropped area, for instance, is the lowest (only 2.8 MT/ha) in Dhuskun whereas the figures for Naubise and Yelung are 4.0 MT and 4.7 MT respectively (Annex 3, Table 5). The resource base, particularly cultivated land, forests and pastureland, seems to be exhausted in this area and is evident from the fact that farmers have begun to use the *'banmara'* plant, which is considered to be of a very low quality, as roofing material and there is a severe scarcity of the traditional roofing material called *'khar'*. Hence, the technological and institutional measures have had several side effects that have adversely affected the sustainability of mountain agriculture (N.S. Jodha and S. Shrestha 1990).

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* One farmer (Mr. Dal Bahadur Basnet, Dhuskun) was found to have four plots; one (0.15 ha) at an altitude of 1,370m with paddy as the main crop because of low land, second (0.04 ha upland) with maize crops at 1,820m where nobody resides, a third plot (0.35 ha upland) with wheat crops at an elevation of 1,880m, and the fourth and last plot (0.25 ha upland) with maize crops at 2, 120m.

Tables 5.1, 5.2, and 5.3 also depict the weakest backward and forward linkages among different components of the farming system in this area. The crop-dominated farming system appears to be the most unsustainable among these three farming systems.

The Livestock - dominated Farming System at Yelung

The situation in the Yelung area is not an encouraging one either. Two elements, particularly of the sustainability matrix (e.g., production flow and resource base), have been affected by their degradation. Not only because of the declining trend of crop yields, but also as a result of population growth, the per capita foodgrain available is believed to have decreased. Therefore, more than one-third of the total foodgrain supply now comes from outside the farm, although there is no strong evidence to support this because of lack of data. However, it is believed that people in the area are now depending more and more on Nepal Food Corporation's supply of grains. At the same time, the rate of seasonal migration is also increasing.

Due to degradation of the forest resource base there is some reduction in biomass supply per unit of cropped area. This is also because of the increase over time in area under cultivated land, due to conversion of forest/pastureland into arable land. However, farmers have not used chemical fertilizers yet to compensate for this. Farmers are of the opinion that fertilizer application destroys the land quality in the long run. It may also be true that perhaps the opportunity cost for compost and FYM application is lower than that of fertilizer use. Moreover, chemical fertilizers are not easily available due to the remoteness.

Despite the fact that the interval between two "*Bukma* Systems" (Annex 9) has been shortened three to five years from the earlier six to seven years, the shifting cultivation method is still in widespread practice. The practice of extensive cultivation may also be the indication of not only the deteriorated condition of the farming system in the area, although it has been realised that the resource base itself is also under strain because the area under forest and alpine pastureland is steadily decreasing. Over time, the genetic biodiversity has reduced because of the fact that some nutritious grasses and fodder tree species are slowly disappearing. Goat keeping with *chauri* farming is vanishing. Biodiversity, which is an important element in the sustainability of mountain farming systems is dwindling and can ultimately lead to unsustainability. Some negative changes have also been noted in terms of water resources; the water mills *('ghatta')* used to be run almost throughout the year in the past, they now run for only 8-10 months. The present open and haphazard grazing practice on the alpine pasturelands and meadows will only lead to deterioration of the resource base, which has already begun. This is also because of public interventions after the resource base, was nationalised. However, the farmers have now begun to manage the pasturelands and meadows under a community management system which is a sign of the sustainability of the system.

Hitherto, the farming system is based on local resources and this is an indication of sustainability, particularly in remote areas like Yelung. The natural resource base (e.g., cultivated land, forest, and pastureland) is not so much degraded as it is in the Dhuskun area. However, some negative changes have been taking place and are leading to unsustainability unless public policies and programmes that are compatible to mountain characteristics are introduced as interventions.

Horticultural Crop-dominated Farming System

The farming system in Naubise has dramatically changed from a cereal crop to a horticultural crop-based system over the last few years. Fruit and vegetable farming is becoming increasingly popular in the area and is bringing several positive changes to the system, for example, an increased level of nutrition of the

people and accumulation of assets (buying more land for cultivation, purchasing improved animals). This is happening due to an increased level of major crop yields and fruit and vegetable production.

Despite the fact that forestry is one of the vital components of the general model of a farming system- it has collapsed to a large extent and the horticultural crop-dominated farming system has appeared as the most promising system among the three studied systems.

If the dependency on forests is the highest in Yelung then it is the lowest in Naubise. Almost all biomass required for crop production and livestock-keeping comes from private land (e.g., homestead, cultivated land). This has enabled farmers to practice stall-feeding to a large extent. The situation has, in fact, brought about some positive changes even in the herd structure. Farmers have begun to replace cattle by buffaloes which are productive animals. Due to the increased level of fodder production, the intensity of stall-feeding is very high. Even the fuelwood supply from the farm is now very substantial.

Similarly, some changes in production flow and utilisation/management practices have been noted. The increased application rate of chemical fertilizers and the increased use of agro-chemicals for storing grains are encouraging. This is the reason (external input supply) why intensive cultivation practices (e.g., multiple cropping) are becoming more and more feasible.

Keeping in mind the population pressure, intensive cultivation is considered necessary. But this option is debatable, particularly in mountain areas, due to its associated side effects. Nevertheless, this practice appears to be feasible for Naubise even for the future, as the supply side of inputs (e.g., improved seeds, fertilizers, agro-chemicals, and existing infrastructure of institutions and support services) appears to be guaranteed or sustainable, and because Naubise is not only accessible but also exposed to new agricultural technologies. Moreover, the largest and the greatest market (Kathmandu Valley) in Nepal is just about 30 km away from the study area.

Some negative changes, however, have also taken place over the time period. Forest and grazing land nearby have been converted into cultivated land. Fragmentation of land is increasing and thus the size of land parcels, mainly due to population pressure, has reduced. The volume of water in each *'kuwa'* (small well) has decreased. However, the changes in resource base are generally positive and encouraging (Table 6.3).

Despite the fact that the present farming system in Naubise has deviated from the traditional management practice to a large extent, the farmers are still adopting several strategies that have evolved through traditional practices (see Annex 8). The strategies of backward and forward linkages, risk hedging (e.g., integrated crop and livestock farming), biomass utilisation, diversification (e.g., cereal and horticultural crop production), and group efforts (emergence of forest resource management at community level) have helped bring the farming system to the present encouraging level. These strategies will be feasible, even in the future, to attain a sustainable farming system amidst increasing population pressure, provided that the new technologies and public interventions (e.g., institutional arrangements for resource management; seeking people's maximum involvement in resource management; pricing policy, which at present is favourable to vegetable farming, and provision of necessary agricultural support services) are compatible to mountain resource specificities and characteristics.

Elements Contributing to Unsustainability/Sustainability of Mountain Farming Systems

Elements Causing Unsustainability of a Farming System

The question arises as to what are the elements that contribute to negative and positive changes leading to unsustainability and sustainability of mountain farming systems? Based on the assessment of the three different types of farming system, four elements emerge as having caused unsustainability of the farming system, and they are - (i) high population pressure on land; (ii) inappropriate institutional interventions; (iii) lack of market integration; and (iv) breaking down of farmers' traditional strategies without the support of appropriate technologies and support services.

The population density per hectare of cultivated land is estimated at about 10 persons in Dhuskun (crop-dominated farming system) and seven persons in Naubise (horticultural crop-dominated farming system). Moreover, the quality of land is much lower in the former area compared to the latter. This indicates that there is high population pressure on the land in Dhuskun. This pressure induced farmers to opt for intensive cultivation (e.g., the cropping intensity of 172% is the highest among the three areas) without good market integration. Hence in the absence of necessary chemical fertilizer supplies and other inputs from the market (e.g., Naubise) for supplementing the reduced quantity of compost materials from the forest and manure from livestock, the productivity of land is low in Dhuskun.

Consequently, even stones/rocks have started to emerge on to the surface of cultivated land in some areas. Because of the lack of employment opportunities caused by the rapid increase in population growth, people have no other choice but land cultivation. Therefore, this high man:land ratio is contributing to the unsustainability of the mountain farming system.

The negative impact of inappropriate institutional interventions has already been discussed in earlier chapters; all forest/pasturelands available in the area are in an extremely degraded situation due to the lack of conservation and protection from the time the Government took over control from community ownership of the resources. Similar is the case of the water resource utilisation pattern, particularly in the context of irrigation systems. Farmers themselves used to form groups for constructing and using irrigation channels in the past, but this has stopped since the Government intervened. Similarly, biomass production and use, which is another form of farmer's traditional strategy, have started to break down. Trees on private land - *kharbari* (marginal land)- were also cut fearing that the Government might consider the land to be part of forest land.

As discussed earlier, lack of regular off-farm employment opportunities in Dhuskun, also forced farmers to use their land intensively. Major sources of 'sideline' activities, viz., construction works (road construction is over now), businesses (Nepal-Tibet border), are temporary and the income generated from them fluctuate every season and every year.

Having briefly discussed the elements contributing to the unsustainability of the farming system, it is relevant to note here that the presence of all or parts of the four elements can indicate the severity of the unsustainability. According to our assessment, all of these four major elements prevail in Dhuskun. This is the reason why the crop-dominated farming system appeared to be the most critical or unsustainable system. In the livestock-dominated farming system located in Yelung, elements (i) and (ii) prevail.

The horticultural crop-dominated farming system, which is considered to be sustainable, could be adversely affected by element (i) in the future, if necessary measures are not taken.

Tables 6.2, 6.3, and 6.4 depict that, along with the negative changes in various types of farming system, some positive changes have also taken place. This is particularly so in the case of Naubise where vegetable farming is widespread. Besides horticultural crops, cereal crops and livestock farming have also improved production and management systems. Productivity of land and livestock are increasing and have contributed towards better living standards, despite the fact that the population is on the increase. There are several factors behind these positive factors, however, and the major elements could be considered as -(i) availability and adoption of new agricultural technology; (ii) market integration; and (iii) biomass production and use on the farm. However, it is difficult to list these elements in order of merit. For instance, market integration has played such a vital role in Naubise that it could be the first major element for transformation of agriculture in the area.

In general, it can argued that the stronger the linkages among the three vital components (e.g., crops, livestock, and forestry) of a mountain farming system, the higher the sustainability of the system. Because of various mountain characteristics (e.g., inaccessibility, fragility, marginality, diversity, 'niche', and human adaptations), a closed system and a local resource-centred farming system have better chances of sustainability. However, the Naubise farming system seems to be heading towards one of these mountain farming systems and hence towards sustainability even though the linkage and contribution of one component, i.e. forestry, to the system is nil. Although the cropping intensity (165% at present) is ever increasing, loss of soil nutrients have not been noted. This is because of two factors: firstly, biomass production at farm level, and secondly, market integration. Farmers, have emphasised the cultivation of perennial crops (e.g., fodder, fuelwood tree plantation) on private land which has greatly substituted for the earlier loss of compost. Farmers have also significantly increased the rate of chemical fertilizer application to about 350 kg per hectare of cultivated land or 212 kg per hectare of cropped area. This situation has, in fact, greatly relieved the pressure on forest land. Consequently, the farmers have been able to protect almost all of the available 50 ha of forest land without use. In the initial phase of five or six years of protection, farmers tried to minimise the use of the forest, so that the forest as one of the vital components of the mountain farming system could be properly integrated. This endeavour could bolster the sustainability matrix in the future.

As soon as the Naubise farming system was integrated into the wider market economy of Kathmandu Valley, the farm management practice began to transform from subsistence to commercial farming. Table 5.2 indicates that there is stronger market integration in Naubise compared to Dhuskun (Table 5.1) and Yelung (Table 5.3). Farmers are now planning to go in for both winter and summer vegetable farming; hitherto winter vegetable cultivation after the main crop (e.g., paddy) was the practice. Because of this integration, farmers have already started to replace cattle with buffaloes ; farmers are buying more and more buffaloes with their increased income, derived mainly from the sale of fruit and vegetables. Because there is a very good market for milk in the valley and the area is accessible by road, milk can be marketed to the valley easily.

The availability of improved agricultural technology has played no less an important role in the area. Farmers now grow almost all cereal crops originating from HYVs. The improved method of compost making and the use of agro-chemicals to store grains have further improved the overall situation of the farming system. There are many farmers who are resorting to improved stoves, which has again contributed to the minimisation of fuelwood requirements; fuelwood is a very scarce commodity in the area. Installation of biogas plants has also played a significant role in saving energy originating from the forest and its by-products.

The strategy of biomass production and its use at farm level has also contributed to many positive changes in the area. Farmers apparently appear to have selected and cultivated even improved cereal crops by employing the strategy of backward-forward linkages in Naubise. It has already been recognised that the area enjoys the highest level of new agricultural technologies (in terms of improved crop cultivation and management practices). In addition, the higher level of main crop yields, the yields of crop by-products (e.g., dry fodder, compost, bedding and roofing materials) per hectare of cropped area is also the highest in the Naubise area (2,620 kg) followed by Dhuskun (2,130 kg), and Yelung (1,785 kg).

7

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

During the last three decades or so several negative changes have taken place in all the areas. Some of them are visible and others are disguised. The most conspicuous visible changes can be taken as increasing landslides, soil erosion, deforestation, and the decreasing level of agricultural crop yields which have been directly affecting the quality of life of the mountain people. Increased out-migration rate and widening hunger gap periods are other crucial negative changes that are emerging, however reasons behind this are not easily perceivable.

This persisting scenario implies that the whole mountain agriculture, in general, is basically moving towards unsustainability. Instead of improvement, deterioration is taking place in the context of all three elements of the sustainability matrix (e.g. resource base, production flow, utilisation/management).

An attempt was made to assess each of the three mountain farming systems in terms of their sustainability, based on the negative as well as on the positive changes that have taken place. Modern agricultural technologies have also brought about several positive changes which can be best seen in the Naubise study site (horticultural crop-dominated farming system). Probably, accessibility and the big ready-made market (Kathmandu) may have greatly strengthened the adoption of improved technology in the area which contributed to increased crop yields, crop diversification, and increased biomass production at farm level thus releasing the pressure on forests.

Dhuskun study site (crop-dominated farming system) has emerged as the most affected area in terms of unsustainability; traditional strategies that helped sustain the system have been overstrained. Backward and forward linkages of the farming system which are a very crucial element of sustainability, particularly in remote and isolated areas, are breaking down. The Yelung study site (livestock-dominated farming system) is moving towards unsustainability, although the situation is not as serious as it is in Dhuskun.

There are several issues and factors that are causing the deterioration of various farming systems. However, four major elements have been identified as causal factors behind the unsustainability of the farming systems and they are (i) high population pressure on land; (ii) inappropriate institutional interventions; (iii) lack of market integration; and (iv) the breaking down of farmers' traditional strategies without the support of appropriate technology and support services. All of these elements are not uniformly distributed in all the farming system study areas. All these elements are found in crop-dominated farming systems, (i) and (ii) in livestock-dominated and (i) in horticultural crop-dominated farming systems. Contrary to this, some major elements contributing to positive changes leading towards sustainability have been identified and they are - (i) availability and adoption of improved agricultural technology; (ii) market integration; and (iii) biomass production and utilisation at farm level. All of them are contributing to positive changes in horticultural crop-dominated farming system.

Finally, appropriate development interventions must be made so as to strengthen/minimise the effectiveness of those elements responsible for sustainability/unsustainability of the mountain farming system in order to achieve the long-term goal of sustainable mountain agriculture. Several farmers' strategies for traditional resource management are still relevant and feasible options, in a changing environment induced by increased demographic pressure and technological innovation, to obtain the above goal.

Recommendations

The general recommendations are to search for ways and means that will strengthen/minimise the elements contributing to the sustainability/unsustainability of each mountain farming system in order to achieve sustainability. Consequently, this approach will strengthen/minimise the positive/negative changes that are taking place in the farming systems. Hence, various operational measures that will contribute towards achieving sustainable mountain agriculture have been identified and recommended for each type of farming system.

As far as the inappropriate institutional interventions are concerned, ways and means to rectify government development interventions are being sorted out. In the case of forests, the Government had already begun to transfer the ownership rights to the people or community through the provision of *panchayat* (former) forest (PF), *panchayat* protected forest (PPF), community forest (CF), lease forest (LF), etc. Some positive impacts of the intervention have now been realised. At least the forest area, which used to be freely grazed and haphazardly lopped, is now quite controlled. However, people's participation in the conservation and protection of forest/pastureland is not as encouraging as expected. This is mainly because the new development intervention does not fully confer the ownership rights of the forest on the people or community. People still fear that the Government might control or interfere again, once the degraded forest/pastureland are reforested/afforested. Therefore, strong legal provisions and their effective implementation are essential. Similarly, farmers' irrigation management systems should be further emphasised.

As mentioned earlier, some of the farmers' traditional strategies are still feasible even for the future. Therefore, they should be revitalised. The other important element is the high population pressure on land and this is not an easy issue to deal with. Despite government efforts to control the high population growth rate, the population in the country as a whole is increasing. In the absence of other employment opportunities, the increased population is dependant on the already overcrowded cultivated land, particularly in the hills and mountains. Consequently, the fragmentation of land is increasing and the per capita suitable landholding size is declining, although the size of landholdings in the region is reported to have slightly increased which is mainly due to the extension of marginal and submarginal land and forest/pastureland. The negative multiplier effects of population pressure in the hills and mountains are numerous and greatly aggravate the causes of unsustainability of mountain agriculture. Therefore, one of the biggest challenges is to tackle this high population pressure. This problem warrants persistent efforts requiring a long time and a great deal of people's motivation.

i) It has been observed that the adoption of improved agricultural technologies (HYV seeds, fertilizers, etc) has proved successful in reversing the trend of declining crop yields resulting from the reduced supply of biomass for livestock feed and composting from forest resources. This approach can be encouraged in accessible areas where modern inputs can be easily made available. However, one has to be cautious regarding the sustainability of fertilizer-based technology in the context of heavy government subsidy in fertilizer cost and the rising global price of petroleum-based products.

ii) Farmers should be encouraged to adopt improved methods of compost preparation and application in order to reduce the losses of plant nutrients in the existing practice. This will increase nutrient supply to crops and augment crop productivity using the same amount of compost materials without exerting any additional pressure on natural resources. Thus, this option may contribute towards improving the sustainability of mountain agriculture. Agricultural extension and training services for educating and motivating the farmers need to be strengthened in order to make this venture successful.

iii) Desirable changes in cropping patterns and crop rotations, such as inclusion of legumes in intercropping or sole cropping, might help improve soil fertility and contribute towards sustainability.

iv) In the '*bukma*' system of cultivation practised in Yelung and in other areas, improvements are possible through planting suitable leguminous forage crops, such as white clover and others, during the fallow period. There could be a two-fold advantage from this practice: firstly, the fertility of the soil can be replenished in relatively shorter periods through fixation of nitrogen by legumes and, secondly, the feed supply situation for livestock will improve.

v) Recently farmers are becoming interested in planting fodder/fuelwood trees on farmlands. This trend should be encouraged by educating and motivating the farmers and making arrangements for the adequate supply of tree saplings of desired species, based on farmers' needs in specific areas. This approach will not only help meet the farmers' requirement for fodder and fuelwood but also contribute to environmental conservation by reducing pressure on forest resources and controlling soil erosion on farmlands.

vi) In the context of rapid deforestation and resulting environmental problems, such as soil erosion, landslides, flooding, siltation, etc, forestry development programmes should receive higher priority than they have received in the past. The knowledge and experiences of the farmers in natural resource management need to be incorporated through increased people's participation at all stages of the programmes. Local people should not only be involved in programme planning and implementation but also made responsible for forest management and utilisation of forest products.

vii) It has been observed that fodder trees are disappearing from natural forests and such trees are seldom included in new plantations undertaken by the Government. In the context of increased shortages of livestock feed in the hills and mountains, adequate priority needs to be accorded to fodder trees on new plantations.

viii) Examine further and find out the ways and means to encourage the use of improved cooking stoves. Their widespread adoption can greatly release the pressure on forests by improving the efficiency of fuelwood. In addition to environmental improvement, the use of stoves will also minimise health hazards caused by smoke emitted by traditional cooking systems.

ix) Replace unproductive animals with more prolific livestock. This practice can also help to reduce the size of livestock but with increased outputs, which are required for household consumption, and cash income that can be invested in productive activities.

x) Encourage stall-feeding practices, particularly in areas with a degraded natural resource base. Widespread adoption will help revitalise forests and pastureland substantially. One glaring example can be observed in the Naubise area.

xi) Improve the nutrient value of available dry fodders with some chemical treatment (e.g., molasses, urea). Effective ways and means must be sought for wider practice of this among farmer communities. Despite the Government's general suggestions during the last several years, this practice has yet to gain popularity.

xii) Local people should be encouraged to manage the natural resource base (e.g., forest, pastureland, etc). Some efforts in this respect have already been made. However, practical measures that ought to be taken by the Government are still lacking. At present, some initiatives have been taken by

farmers themselves. One example can be quoted from the Yelung site where one user group has been formed to effectively use and manage alpine pastureland and meadows for *chauri* farming.

xiii) Emphasis on the production of low-weight, high-value products. Installation of processing units for agricultural and livestock products will be very effective in this respect. Farmers can be encouraged to establish a small 'cream separator' unit to produce value-added products. This would be an effective, operational measure for areas that are beyond the reach of the Dairy Development Corporation.

xiv) Other agricultural support services can be equally helpful in improving the mountain farming system.

xv) A multidisciplinary approach in the research and development of rainfed farming, integrated crop-livestock-forestry farming, and local resource-based, low input use technology are the real challenges for the future development of sustainable mountain agriculture.

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Annex 1

Criteria for the Selection of Study Site by Farming System

Criterion/Parameter	Farming System		
	Crop-dominated	Horticultural Crop-dominated	Livestock-dominated
1. Accessibility			
- Walking distance from road	3 - 6 hours	Along the perhiphery of road	3 - 6 hours
2. Aspect	S, S-E, S-W	S, S-E, S-W	-
3. Elevation	1000 - 2500 metres	700 - 1500 meters	1200 - 3000 metres
4. Slope	20 - 30°	-	20 - 30°
5. Vertical Agriculture[1]	Vertical Agriculture	-	-
6. Cropping Pattern	Maize-dominated	Vegetable Cereals	Maize-Potato
7. Traditional/Improved Agriculture	Fair	Good	Fair
- Use of Improved seeds	Fair	Good	Fair
- Use of chemical fertilizer	Fair	Good	Fair
8. Soil Type (Land System)	Loam to Sandy Loam	Loam to Sandy Loam	-
9. Natural Resources (Forest/Grazing land/pasture land/shrubland)	Medium Profile	Low to Medium Profile	Medium to High Profile

Note: S = South, N = North, E = East, W = West

1 Vertical agriculture or farming system indicates a situation where a long series of upland and lowland terrace cultivation prevails and is along nearby forests.

Demographic Features of Sample Households at Different Study Sites

Site and Farm Size	Family Size (No.)			Economically Active Members (No.)			Dependency Ratio	Literacy [1] (%)		
	Male	Female	Total	Male	Female	Total		Male	Female	Total
Naubise										
Small	3.40	2.90	6.30	2.30	2.10	4.40	0.40	47	55	51
Medium	3.00	3.25	6.25	2.25	2.12	4.37	0.43	79	73	76
Large	3.92	4.50	8.42	2.50	2.83	5.33	0.58	70	61	65
Overall	3.50	3.63	7.13	2.37	2.40	4.77	0.49	65	62	64
Dhuskun										
Landless	3.00	3.00	6.00	2.00	2.00	4.00	0.50	0	0	0
Marginal	2.33	2.33	4.66	1.33	1.33	2.66	0.75	29	29	29
Small	2.25	2.31	4.56	1.56	1.19	2.75	0.66	44	43	44
Medium	2.29	2.57	4.86	1.43	1.57	3.00	0.62	69	61	65
Large	4.33	4.00	8.33	3.33	2.33	5.66	0.47	85	92	88
Overall	2.50	2.57	5.07	1.70	1.43	3.13	0.62	50	48	49
Yelung										
Marginal	2.83	2.61	5.44	1.89	1.94	3.83	0.42	47	51	49
Small	3.00	2.17	5.17	2.50	1.33	3.83	0.35	39	54	45
Medium	3.50	2.50	6.00	1.83	1.67	3.50	0.71	43	60	50
Overall	3.00	2.50	5.50	2.00	1.77	3.77	0.46	44	53	48

Source : Household Survey, APROSC 1989.

1 Economically active members of the family include those persons who are 10 years old or above.

Crop Production

Cropped Area

Crop production in the study area is highly diversified and cereal is the dominant crop. The types of crop grown are mainly influenced by family needs for food, and owing to small farm sizes farmers usually do not grow market-oriented cash crops. Maize, paddy, wheat, and millet are important crops grown in the study area. Table 1 shows the distribution of cropped area as percentage of cultivated land at different study sites.

Table 1: Distribution of Cropped Area as Percentage of Cultivated (Operated) Land

Total of the Sample Households

Crops	Naubise		Dhuskun		Yelung	
	Cropped Area (ha)	% of Cultivated Area	Cropped Area (ha)	% of Cultivated Area	Cropped Area (ha)	% of Cultivated Area
Normal Paddy	11.72	40	4.99	32	-	-
Early Paddy	0.89	3	-	-	-	-
Wheat	7.72	27	0.52	3	3.21	38
Maize	18.04	62	0.52	3	3.21	38
Millet	1.18	4	8.90	57	1.64	19
Potato	0.89	3	-	-	1.88	22
Barley	-	-	-	-	0.33	4
Buckwheat	-	-	-	-	0.35	4
Sugarcane	1.16	4	-	-	-	-
Oilseeds	1.31	5	0.31	2	-	-
Vegetables [1]	4.87	17	-	-	-	-
TOTAL	47.78	165	26.91	172	9.84	115

Source : Household Survey, APROSC 1989

1 Includes brinjals (5%), capsicums (5%), tomatoes (3%), cauliflowers (1%), beans (1%), and cucumbers (1%)

Cropping Patterns

Cropping patterns in the study area are usually maize-based on rainfed uplands and paddy-based on irrigated lowlands although potato-based patterns are also common on uplands at the Yelung site. Both mono-cropping as well as multiple-cropping are practised in the study area. The cropping patterns at different study sites are presented in Table 2.

Table 2: Existing Cropping Patterns and Proportion of Cultivated Land Covered by Them at Different Study Sites

(In Percentage)

Cropping Patterns	Naubise			Dhuskun			Yelung
	Lowland	Upland	Total Land	Lowland	Upland	Total Land	Upland
Mono-cropping	12.0	54.6	37.3	60.7	13.6	28.6	68.6
Normal (N) Paddy-Fallow	12.0	-	4.8	60.7	-	19.3	-
Maize-Fallow	-	47.9	28.5	-	9.1	6.2	9.2
Wheat-Fallow	-	-	-	-	4.5	3.1	37.6
Potato-Fallow	-	-	-	-	-	-	17.9
Barley-Fallow	-	-	-	-	-	-	3.9
Sugarcane	-	6.7	4.0	-	-	-	-
Double Cropping	82.6	45.5	60.5	39.3	86.4	71.4	23.4
Early Paddy-N. Paddy	6.2	-	2.5	-	-	-	-
N. Paddy-Wheat	23.4	-	9.5	-	-	-	-
N. Paddy-Maize	12.4	-	5.0	39.3	-	12.5	-
N. Paddy-Vegetables	39.8	-	16.1	-	-	-	-
N. Paddy-Oilseeds	0.8	-	0.3	-	-	-	-
Maize/Millet	-	6.8	4.1	-	83.1	56.7	19.2
Maize-Potato	-	4.2	2.5	-	-	-	-
Maize-Oilseeds	-	7.1	4.2	-	2.9	1.9	-
Maize-Vegetables	-	1.2	0.7	-	-	-	-
Potato-Buckwheat	-	-	-	-	-	-	4.2
Tripple Cropping	5.4	2.2	-	-	-	-	-
N. Paddy-Wheat-Maize	4.0	1.6	-	-	-	-	-
E. Paddy-N. Paddy Potato	1.4	0.6	-	-	-	-	-
Fallow	-	-	-	-	-	-	8.0

Source : Household Survey, APROSC 1989.

Table 3: Cropping Intensities at Different Study Sites

(In per cent)

Sites	Farm Size				
	Marginal	Small	Medium	Large	Overall
Naubise					
Lowland	-	189	198	192	193
Upland	-	167	160	138	145
Average	-	175	182	157	165
Dhuskun					
Lowland	100	137	164	119	139
Upland	200	184	189	185	186
Average	186	170	182	158	171
Yelung					
Lowland	-	-	-	-	-
Upland	107	123	116		115
Average	107	123	116	-	115

Though the farmers could not provide quantitative information regarding the changes in cropping intensity, they have feelings that cropping intensity has increased over time. Inclusion of additional crops, such as early paddy, spring, maize, and vegetables, under multiple cropping on lowlands in Naubise and Dhuskun, and shorter fallow periods, from 5-6 years to 3-4 years, under shifting cultivation at Yelung support the increment in cropping intensity over time. Discussions with the farmers in Naubise and Dhuskun revealed that the coverage of improved varieties has increased over time.

Input/Use

Table 4 shows the coverage of improved crop seeds at different study sites. Discussions with the farmers in Naubise and Dhuskun revealed that the coverage of improved crop varieties has increased over time.

Table 4: Proporption of Farmers[1] Growing Improved Varieties and the Cropped Area[2] Under It

Crops	Naubise		Dhuskun		Yelung	
	Farmers	Cropped Area	Farmers	Cropped Area	Farmers	Cropped Area
Early Paddy	100	100	-	-	-	-
Normal Paddy	93	92	78	76	-	-
Wheat	100	100	92	83	0	0
Maize	65	72	40	38	-	-
Potato	100	100	-	-	90	79
Vegetables	100	100	-	-	-	-

Source : Household Survey, APROSC 1989.

1] Percentage of farmers growing improved crop varieties calculated from the total number of respective crop growers.

2] Percentage of cropped area under improved varieties calculated from the total area under respective crops.

Organic Manure

Compost is the major source of soil nutrient for agricultural land in the study area. Table 5 shows the average rates of compost application in different crops in the three study sites.

Regarding the changes in the average rates of FYM/compost application over time, mixed responses were recorded. Some farmers reported that the average rates increased because of increased adoption of stall-feeding practices in livestock. However, a majority of the farmers believe that the average rates of compost application per unit of cropped area decreased due to reduced supply of litters, bedding materials, and fodder from forests, reduced size of livestock-holding, and increased cropping intensity.

Table 5: Average Rates of FYM/Compost Application by Different Crops

(In MT/ha)

Crops	Naubise						Yelung
	Low-land	Upland	Average	Low-land	Upland	Average	Upland Average
Early Paddy	2.29	-	2.29	-	-	-	-
Normal Paddy	1.49	-	1.49	1.46	-	1.46	-
Wheat	1.56	1.96	1.79	-	2.16	2.16	2.61
Maize	2.74	5.00	4.76	2.33	5.59	5.07	6.10
Millet	-	1.06	1.06	-	0.61	0.61	1.66
Potato	8.37	10.25	9.91	-	-	-	10.19
Barley	-	-	-	-	-	-	1.23
Buckwheat	-	-	-	-	-	-	2.60
Sugarcane	-	4.74	4.74	-	-	-	-
Mustard	1.50	0.28	0.36	-	0.65	0.65	-
Vegetables	11.43	11.25	11.42	-	-	-	-
Average per unit cropped area	3.73	4.23	4.00	1.71	3.20	2.82	4.74
Average per unit cultivated area	7.22	6.16	6.58	2.38	5.97	4.83	5.44

Source : Household Survey, APROSC 1989.

In Naubise almost all farmers apply chemical fertilizers to all crops grown, apart from millet in which only 43 per cent of the growers use fertilizers on about 44 per cent of the cropped area.

The average rates of fertilizer used for different crops are given in Table 6. Chemical fertilizers form the major source of plant nutrients for crop production at Naubise site, where the average rate of fertilizer application is quite high and the average dose of fertilizer applied is found to be highest for vegetables followed by wheat, paddy, sugarcane, and maize.

Table 6: Average Rates of Fertilizer Use in Different Crops by Land Types

(In N:P:K kg/ha)

Crops	Naubise			Dhuskun		
	Lowland	Upland	Average	Lowland	Upland	Average
Early Paddy	63:18:0	-	63:18:0	-	-	-
Normal Paddy	64:29:0	-	64:29:0	13:0:0	-	-
Wheat	68:32:0	65:38:0	66:35:0	-	22:10:0	13:0:0
Maize	43:35:0	50:26:0	49:27:0	16:7:0	17:8:0	17:8:0
Millet	-	16:7:0	16:7:0	-	1:0:0	1:0:0
Potato	54:31:0	36:29:0	39:29:0	-	-	-
Sugarcane	-	57:17:0	57:17:0	-	-	-
Mustard	33:33:0	38:38:30	38:38:0	-	6:0:0	6:0:0
Vegetables	71:41:23	80:60:30	71:44:23	-	-	-
Per Hectare Cropped Area	64:33:5	51:28:0	57:30:2	14:2:0	10:4:0	11:4:0
Annual per Hectare of Cultivated Land	124:63:9	74:40:0	94:49:4	19:3:0	18:8:0	19.:7:0

Source : Household Survey, APROSC 1989.

Crop Yields

Crop yields are determined mainly by soil fertility, availability of irrigation facility, climate, and the level of technology, including inputs used by farmers. The average yields of crops grown at different study sites are given in Table 7.

Table 7: Average Crop Yields at Different Study Sites

(in MT/ha)

Crops	Naubise		Dhuskun		Yelung	
	Main Product	By-product	Main product	By-product	Main Product	By- product
Early Paddy	2.97	3.24	-	-	-	-
Normal Paddy	2.70	3.21	1.72	-	-	-
Wheat	1.68	2.72	1.23	1.15	1.15	2.10
Maize	1.77	3.38	1.49	1.53	1.53	2.83
Millet	1.03	1.72	0.95	0.88	0.88	1.69
Potato	5.95	-	-	5.54	5.54	-
Barley	-	-	-	0.66	0.66	1.19
Buckwheat	-	-	-	0.90	0.90	1.39
Sugarcane	15.40	7.50	-	-	-	-
Mustard	0.66	0.82	0.51	-	-	-
Cauliflower	11.75	-	-	-	-	-
Brinjal	26.63	-	-	-	-	-
Capsicum	11.98	-	-	-	-	-
Tomato	21.12	-	-	-	-	-
Cucumber	9.21	-	-	-	-	-
Beans	3.95	-	-	-	-	-
Onion	15.21	-	-	-	-	-
Garlic	6.60	-	-	-	-	-

Source : Household Survey, APROSC 1989.

Farm Trees

Trees are grown on farmlands mainly for fruit, fodder, fuelwood, and timber. The importance of farm trees has increased significantly in the context of increased demand of tree products and dwindling forest resoruces. Table 8 shows the average number of trees per farm by farm size at different study sites.

Annex 3

Table 8: Average Number of Farm Trees per Household

Site and Farm Size	Fruit Trees	Fodder Trees	Other Trees	Total
Naubise				
Small	27.9 (19.0)	13.4	13.8	55.1
Medium	37.9 (24.7)	31.0	37.8	106.7
Large	97.0 (41.7)	27.7	55.2	179.9
Overall	58.2 (29.5)	23.9	36.7	118.8
Dhuskun				
Marginal	0.3 (0.3)	1.7	0.3	2.3
Small	1.3 (0.8)	4.0	3.4	8.7
Medium	1.8 (1.1)	7.0	16.1	24.9
Large	4.4 (1.9)	6.3	21.6	32.3
Overall	1.6 (0.9)	4.7	8.1	14.4
Yelung				
Marginal	0.0	26.1	36.9	63.0
Small	0.0	19.8	27.1	46.9
Medium	2.2 (1.0)	19.2	222.4	241.6
Overall	0.4 (0.2)	23.5	72.0	95.9

Source : Household Survey, APROSC 1989.

Note: Figures in parentheses indicate the number trees at bearing stage.

Annex 4

Table 1: Annual Farm Cash Income Per Household By Source and Study Site

Source	Naubise		Dhuskun		Yelung	
	Rs.	%	Rs.	%	Rs.	%
Horticultural Crops	17265	80.5	-	-	-	-
Cereal Crops	2210	10.3	72	53.3	100	1.9
Livestock	1985	9.2	63	46.7	5248	98.1
T O T A L	21460	100.0	135	100.0	5348	100.0

Source : Household Survey, APROSC 1989.

Table 2: Total Annual Cash Income Per Household by Source and Study Site

Source	Naubise		Dhuskun		Yelung	
	Rs.	%	Rs.	%	Rs.	%
Farm						
- Horticultural Crop	17265	44.1	-	-	-	
- Cereal Crop	2210	5.6	72	1.8	100	0.6
- Livestock	1985	5.1	63	1.6	5248	34.3
- Off-farm	17706	45.2	3893	96.6	9954	65.1
TOTAL	39166	100.0	4028	100.0	15302	100.0

Source : Household Survey, APROSC 1989.

Table 1: Annual Animal Feed Supply by Source and Type of Feed, and Study Site

	Unit	Study Site		
		Naubise	Dhukshun	Yelung
Crop Land				
- Tree Fodder	kg	497	100	187
- Grass Fodder	kg	4275	3392	2568
- Dry Roughage	kg	2883	1778	510
- Concentrates	kg	275	51	9
Forest/Pastureland				
- Tree Fodder	kg	-	61	5202
- Grass Fodder	kg	-	2219	987
- Grazing	hrs	298	686	2018
Purchased from Market				
- Concentrates	kg	12	13	39

Source : Household Survey, APROSC 1989.

Annex 6

Table 1: Land Use of Naubise *Panchayat* by Ward

(in hectare)

Ward #	Physical Area	Residential Area	Forest Area	Pasture/ Rocky Area	Cultivated Land (ha)			
					Low land			
					Irrigated	Rainfed	Upland	Total
1	214	4	51	1	30	20	78	128
2	341	10	50	3	50	12	89	151
3	204	5	34	5	25	1	80	106
4	458	10	70	3	40	5	91	136
5	249	10	55	26	19	5	86	110
6	127	6	45	13	30	3	53	86
7	362	15	66	13	96	5	167	269
8	242	7	62	11	13	2	194	209
9	125	3	31	1	32	5	63	100
TOTAL	2322	70	464	76	335	58	901	1294

Source : Village *Panchayat* Secretariat, Naubise, 2045 (1988)

Table 2: Existing Calorie Intake Per Capita Per Day By Source and Study Site

Particular	Naubise		Dhuskun		Yelung	
	Calorie	%	Calorie	%	Calorie	%
Farm						
Food Crops (Cereals mainly)	1698		1663		526	
Fruits and Vegetable	76		-		-	
Animal Food	130		15		78	
Outside Farm						
Food Crops (mainly cereals)	106		70		383	
Fruits and Vegetables	1		-		1	
Animal Food	1		-		1	
Overall						
Food Crops (mainly cereals)	1804	89.7	1733	99.0	909	91.9
Fruits and Vegetables	77	3.8	-	-	1	0.0
Animal Food	131	6.5	15	1.0	79	8.1
	2012	100.00	1748	100.0	989	100.0
Total Calorie Intake						
Farm	1904	94.6	1678	96.0	604	61.1
Outside Farm	108	5.4	70	4.0	385	38.9
	2012	100.0	1748	100.0	989	100.0

Source: Household Survey, APROSC 1989.

Note: Based on the information provided by B.V. Ilaco, 1981, and Burton, 1973, food commodities have been converted into calories as per the calorific values per kilogramme of food items in edible form as follows: rice-3600, wheat-3340, maize-3560, millet-3320, oilseeds-5740, sugarcane-600, fruits-550, vegetables-250, milk-1010, and meat-710. The conversion coefficients from raw food items into edible form are 0.6 and 0.4 for rice and other crops respectively (Asian Development Bank 1982).

Table 1: Farmers' Strategies and Their Operational Measures in Different Types of Farming System: A Comparative Table

Farmers Strategies	Operational Measures by Type of Farming System		
	Crop-dominated	Horticultural Crop-dominated	Livestock-dominated
1. EXTENSIVE/ INTENSIVE CULTIVATION AND MANAGEMENT PRACTICES	1.1 Intensive cultivation practices (medium level) (i) Higher level of cropping intensity (ii) Absence of abandoned land	1.1 Intensive cultivation practices (high level) (i) Higher level of cropping intensity ii) Absence of abandoned land	1.1 Extensive cultivation practices (i) "Slash and burn" cultivation practice, e.g., "BUKMA SYSTEM" - reduced interval period from one Bukma cultivation to another Bukma. Interval period is now 3-5 years instead of 4-6 years as used to be few years back. (ii) Presence of abandoned land
	1.2 Intensive management practice	1.2 Intensive management practice	1.2 Extensive management practice
	1.2.1 Crop i) Introduction of new crops - maize in lowland after paddy - wheat in upland ii) Introduction of new varieties (crop) - *pokhreli* in paddy	1.2.1 Crop i) Vegetables in lowland after paddy - introduction of new varieties - RR21 in place of local - CH45 in place of *ghaiya* paddy - CH45 in place of millet (steadily) - sugarcane crop which used to be major cash crop has completely disappeared due to (i) low price (ii) higher occurence of diseases and pests	1.2.1 Crop i) No introduction of new crops ii) introduction of new varieties - improved potato (red) - despite higher yield in case of improved potato, farmers also cultivate local in order to hedge risk that may arise from disease and drought