PATTERN AND IMPLICATIONS OF LAND COVER - LAND USE CHANGES IN A CLUSTER OF HIMALAYAN VILLAGES

DISSERTATION
submitted to the
Jawaharlal Nehru University
in Partial Fulfillment of the Requirement for the Degree of
Master of Philosophy

JAGDAMBA PRASAD

SCHOOL OF ENVIRONMENTAL SCIENCES
JAWAHARLAL NEHRU UNIVERSITY
NEW DELHI 110067
July 2002

जवाहरलाल नेहरू विश्वविद्यालय
JAWAHARLAL NEHRU UNIVERSITY
SCHOOL OF ENVIRONMENTAL SCIENCES
NEW DELHI-110067

CERTIFICATE

The research work embodied in this dissertation entitled **"PATTERN AND IMPLICATIONS OF LAND COVER - LAND USE CHANGES IN A CLUSTER OF HIMALAYAN VILLAGES"** is done by **JAGDAMBA PRASAD** under the supervision of Dr. K.G. Saxena in partial fulfillment of the requirements for the degree of Master of Philosophy. The work is original and has not been submitted in part or full for any other degree or diploma to any university.

20.7.2002
Jagdamba Prasad
Candidate

New Delhi.
20 July 2002

Prof. K. G. Saxena
Supervisor

Prof. K. Dutta.
Dean, SES

DESTINY OBSCURED!

To

The innocent futures, who will have to seek their life within the resources left

ACKNOWLEDGWMENTS

At the very outset I wish to offer my sincere thanks to large number of well wishers who have extended co-operation, help and guidance in bringing my dissertation to light.

I take this privilege to record my heartfelt gratitude to Dr. K.G. Saxena, Professor, School of Environmental Sciences, Jawaharlal Nehru University, whose inspiration, valuable advice, expert guidance and continuous encouragement that have been the only impetus to me to undertake this study.

I express my thankfulness to Prof. K. Dutta, Dean, School of Environmental Sciences, JNU for moral support, kind help and providing necessary facilities from the school.

I feel a sense of pride to pay honour to Prof. P.S.Ramakrishnan who has been a source of inspiration and vitality all the times .

I owe my acknowledgement to Dr.R.K. Makhuri, G.B.Pant Inst. of Himalayan Environment and Development, Garwal unit, for his support and invaluable suggestions during my field studies.

I express my obligation to the staff members of library of JNU, World bank, TERI, IARI, IIT, NML in Delhi, WWI, FRI, CSWRTI, BSI in Dehradun and different other libraries for their cooperation.

I am grateful to my School for its infrastructural facilities, its non-teaching staff for their cooperation, teaching staff for their guidance, and research scholars for their support.

I appreciate the help and support of my research seniors, Ravindra Gavali, S. Chandrasekhar, Kirtika Singh, Abdul Wakeel, Bhaskar Sinnha. and Anup Das.

If any one has greatest contribution apart from my supervisor he is Narendra Kumar Sahoo, for he always cooperated me from fieldwork to completion of the dissertation, in the extremely stressful moments.

My fellow researches Sutapa, Vivek, P.R.Kadam, Vijay Shridhar, Minaskhi, Hafij Faridi, Vinay, Seema, Deepak Singh and all other classmates' created an intellectual and homely milieu. Nevertheless junior researchers Indrani and Deepika helped me variously

My friends Prabhu, Naman,, Sunil, Sivprasad, Vishwanath, Vishwadeepak, Mehata and Pravir have always been source of love and aspirations.

The contributions and joyful ambience of my hostel companions Bal ram, Ganga Sahay, V.K.Singh, Sanu, Aditya, D. P. Saxena and many others are unforgettable.

The unexpressed and untold love, patience and encouragement of my family are gratefully acknowledged.

I acknowledge the financial support provided by Rishikul Association and CSIR to undertake research work.

Not to forget, there are many hidden hands of blessings of my present and past teachers, and my well-wishers.

(JAGDAMBA PRASAD)

Contents

List of Tables

List of Figures

INTRODUCTION

Globally hills and mountains are esteemed as harbour of rich geographical, biological and cultural diversity with less disturbed ecological integrity than surrounding lowland civilization. But for the last few decades burgeoning population with its current pattern of resource use has led to degradation of environment and natural resources particularly in mountain areas of developing countries

There are persistent negative trends among different variables relating to resource base, production flows and resource management system in these areas. Ironically these symptoms of un-sustainability have emerged despite increased cautious efforts towards the development imperatives. The overall situation is both a cause of concern and reason for reappraisal of prevailing resource use practices and underlying drivers of system dynamics (Rieger, 1981).

A search for a way out for mountain agriculture in such a situation calls for a focused enquiry into the circumstances conditioning the current performance and future possibilities in mountain agriculture. This could be done at both the farm or village level as well as the policy and programme level.

Mountain agriculture has been focused of extensive research for last two decades. There are indications that increasing concern for monetary economy in subsistence oriented local communities has resulted into a number of land use changes. A shift from conventional agriculture to cash crop cultivation and commercial vegetable farming has been observed. The consequences of these changes upon ecological integrity and their socio-economic implications have not been studied adequately.

Our understanding at household level, which is recently recognized as important unit in landscape dynamics and environment impact assessment, is not much comprehensive. Production, consumption, storage and market transaction pattern and concerned household behavior as a function of degree of self reliance with agriculture are still not much revealed in mountain context. A quantified account of these parameters is expected not only to identify household level driver of contemporary changes in the system but also to give an assessment of risk management potential at the level. The statistics on degree of self-reliance and risk management would be of immense importance for a decentralized mode of development suitable for mountain communities.

Again statistical evidences to sustain either of the two options are limited or more specific to particular context of ecological condition and market equations.

There is an urgent need to go for a critical appraisal of such land-use changes in order to avoid possible pitfall, which might disturb system resilience even irreversibly.

1.1 Mountain Agriculture: An Overview

Agriculture is the dominant sector of mountain regions, which encompasses all land-based activities such as cropping, animal husbandry, horticulture and forestry. It does not only sustain the bulk of mountain population but also forms the major context to which whole question development in mountains relates. Infact it can serve as a focal point for sustainability intervention for the system (Jodha et al., 1992).

Mountain agriculture has acquired a number of features to manage problems and opportunities created by mountain characteristics such as inaccessibility, fragility and diversity. The limited transport and communication infrastructure, unavailability of reliable market and production inputs and high variations in micro-climates, accompanied by large families living on small fragmented farms on hill terraces and steep slopes, have led the farmer in mountain region to adopt the subsistence oriented mixed farming system (Yadav, 1992).

The system consists of a great variety of crops including perennial fruit and fodder trees and different species of livestock on the farm. The system produces food year round and provides continuous employment for unskilled labours. Forest supply fuel-wood, fodder compost, timber and food to the system, forming its integral components. This integration is further enhanced lay conventional agro-forestry practices (Yadav, 1992).

Thus the system, with its diversified elements, maintains various regenerative processes and high degree of stability and self-reliance. Only recently scientific community could realise sustainability implication from their traditional agricultural practices of mountain areas (Sharma et al., 1991).

1.2 Field Scattering And Risk Management In Mountain Agriculture

Mountain communities use several strategies to buffer themselves from the risk of an unreliable supply of staple food. Storage, inter-zonal exchange of products, and diversified production are key factors. Storage reduces risk by availability of produce through time; one year's surplus can cover the next year's shortfall (McRae, 1979; Browman, 1987). Exchange spreads risk across productive units and agro-ecological zones; those experiencing adequate production share with those who do not, knowing that reciprocity will occur should their fortunes later turn bad (Brush, 1977a, 1977b; Guillet, 1983; Weinstein *et al.*, 1983). Diversified production allows a household to minimize risk within a production year by distribution risk over the landscape and across different crops (Guillet, 1981a; Brush, 1986; Browman, 1987). These strategies have combined to create a resilient adaptation to counter environmental unpredictability.

Scattering a household's agricultural fields over the landscape increases travel and transport costs. A risk minimization argument can help explain this phenomenon by demonstrating that there are important benefits to be gained by this practice. Colloquially, risk usually is associated with variance, and both are judged undesirable. However, for analytical clarity the meaning of the two must be separated. Risk is the probability of loss (e.g., of life, significant income, nutritional health, or social status). Variance is a statistical concept referring to the spread of values in a distribution. It is suggested that if the fluctuations in yield of scattered plots are not strongly positively correlated, then a household that pools the harvests of several fields can reduce variance from year to year if they relied instead on a single plot. Reduced variance, provided it does not incur too great a cost in average production, reduces the risk of subsistence shortfalls. However, under some circumstances increased variance is advantageous in avoiding risk.

Evolutionary ecologists (Caraco et al., 1980; Caraco, 1981; Stephens and Charnv, 1982), agricultural economists (Roumasset, 1976), and economic historians (Mc Closkey, 1975, 1976) have independently proposed similar models to assess the effectiveness of various risk reduction behavior which can be represented by a probability distribution. It is characterized by a mean reward (income for the economist, calories or units of fitness for the ecologist) and variance around it.

1.3 Current Land Use Changes And Associated Risks

Today, however, the system stands at a critical threshold where it is increasingly unable to meet the burgeoning demand of rapidly growing population. Small holding, less economic opportunities and other constraint in resource use have compelled people to go for a number of adaptation like intensification of agriculture, shift in choice of crop: from staple crops to cash crops, exploitation of altitudinal zones or 'niche', and changing pattern of migration. These however, add misery to the system. (Sharma et al., 1991)

Modern agricultural technology in other hand, are expensive, environmentally disruptive and often insensitive to mountain conditions. With environmental and economic limits to their technology based on fossil fuel consumption and high yielding variety adoption or with current mode of implementation their contribution in enhancing system efficiency is almost insignificant.

In many mountain regions of the world, an explicit shift from conventional agriculture to commercial vegetable farming is observed with an increased level of economic penetration, the choice of crop and cropping pattern in these areas is increasingly being guided by market force and value system rather than their empirically established conventional pattern. This shift might be associated with a number of negative consequences like decline in agro-biodiversity, reduced stability, more dependency over market and increased level of risk compared to that with the conventional pattern

1.4 Agriculture In Garhwal Himalaya

The Garhwal Himalaya has a long history of subsistence economy, with agriculture being the core component, in which over 80% of the people are involved. Realising the great variations in the altitude, topography, climate, forest resources, availability of irrigation water, and socio-economic and cultural factors, one could reasonably expect a variety of land use patterns in the region. If ecological conditions are superimposed on this then the heterogeneity becomes very complex. Broadly, three basic farming systems have been identified for the Central Himalaya, of which this region is a part. All the systems are livestock based, and form a spectrum of economic activity ranging from nomadism to settled agriculture (Singh et al., 1984). Settled agriculture, which is a mixed crop livestock-farming system predominates across a vast area between 300 m and 2500 m above sea level (ASL) on terraced agricultural fields, except in the narrow strip of foothills where these are flat. The terraces are carved out from the mountain slopes, sometimes greater than 50°. The greater part of the agriculture is practiced under rainfed conditions. According to one estimate only around 10% of land is under irrigation in the Central Himalaya (Ralhan et al., 1992). The total gross cropped area of the Garhwal Himalaya is about 15% and the net sown area is 9.62% of the geographical area (about 30,000 km^2) of the region (Swarup, 1993). The traditional agroecosystem of this region is mainly operated by animal (bullock) power and human labour in which women play a crucial role. Rainfed agriculture mostly produces three crops are taken in a year. A year is built around two major cropping seasons, i.e. kharif (April-October) and rabi (November-March). Paddy, finger millet, hog-millet, foxtail millet, barnyard millet, maize and a variety of pulses are the main components of the kharif season, while wheat, mustard, lentils, barley and peas are the main crops of he rabi season. Generally, mixed cropping is practiced on rainfed land during the above season while on irrigated land it is mostly practiced during rabi season.

As elsewhere in the Himalaya the agriculture of the Garhwal region is closely linked with the forestry sector either through its dependence upon the forest or directly through traditional agroforestry systems. Studies from the Central Himalaya by Singh et al. (1984), Pandey & Singh (1984), Negi et al. (1989), Singh et al. (1992), Ralhan et al. (1992) and Rai (1993) indicate that the agriculture practiced requires a massive consumption of forest resources. However, the position at present is that only 24.9% (7473 km^2) of Garhwal Himalaya is now forested and only 4.1% of the area has a forest with greater than 60% crown cover (Singh et al., 1984). The situation has deteriorated further, sonce then (Ramakrishnan et al., 1992). Further, 85% of all agricultural land already suffers from severe erosion problems due to the shallowness of the soil and its acute slope (Negi & Singh, 1990). As a result of these problems recent years have witnessed a process of land abandonment due to the magration of young people from the region in search of new jobs and a 10% decrease in the livestock population between 1972 and 1986 (Swarup, 1993).

In India, in spite of a thorough and interdisciplinary study by Ramakrisnan (1992) from northeastern India and studies such as that of Mitchell (1979), there have been only a few attempts at this approach to the study of agroecosystems. Fortunately, there has been a renewed interest in traditional systems throughout the world. The tow review books by Altieri & Leibman (1988) and Gliessman (1989) are indicative of the concern to base agriculture on a sustainable basis.

Few studies and reports indicate that growing concern for monetary economy has resulted in a shift from staple crop to cash crop cultivation and commercial vegetable farming in Himalayas (Semwal et al., 1996; Poudel et al., 1999; Harden, 1996). But there has been no attempt to analyse different consequences of this shift upon ecosystem health as well as subsistence level of staple food production and associated risk.

Guided by above consideration a study was carried out in a mid altitude landscape of Garhwal Himalaya. Three villages from agriculture landscape were selected and sampled for household level analysis.

1.5 Objectives

The objectives of the present study are:

- Firstly to test whether commercial vegetable cultivators with a given landholding and resource base in a mid-altitude Himalayan landscape are more likely to face risk of failure in maintaining subsistence level of staple crop production compared to conventional farmers. Field scattering, as a means of risk management, is taken as criteria of risk assessment.
- Secondly, to trace out land use - land cover changes that correspond to the shift, the community underwent in the course of its transformation from conventional mode of production to market oriented commercial agriculture.

1.6 Scheme Of The Study

To pursue the objectives the study was designed to incorporate two profiles of analysis:

1. *Comparative Risk Assessment* (between vegetable cultivators and conventional farmers of Narayankoti village.) The study includes two steps,

which determine *A: Whether the field scattering model for agricultural risk management would be applicable in the present context.* If the fluctuations in yield are localized in their spatial occurrence, scatteredness of fields would reduce production variance and hence would act as a means of risk management *B: Whether vegetable cultivators of the study area fails to cultivate their scattered landholdings with as much efficiency as shown by conventional peasants.* Taking distance as measure of scatterness and crop yield as manifestation of efficiency, the assumption would be supported statistically if:

(i) In distant parcels of land, the fields owned by the vegetable cultivators show significantly less yields of a staple crop than adjacent fields possessed by conventional farmer. And

(ii) In proximate parcels of land, the fields owned by the vegetable cultivators do not show as lesser yield as in case of distant parcel, compared to adjacent proximate parcel owned by conventional farmers. Statistically the same thing would be pronounced if it shows any of the following possibilities:

- In the proximate parcel, fields owned by each community do not show significant difference in crop yields. OR
- In the same parcel fields owned by vegetable cultivators show a yield higher than that shown by adjacent fields owned by conventional farmers. OR
- The former is lesser than the latter but at a level of significance, which is lesser than that referred in case of comparing yield for the two farmer communities in distant parcels.

2. ***Comparative studies of land use – land cover*** (between vegetable cultivators and other three communities of conventional farmers.) It involves a comparison between these communities in order to identify village level changes in land use and land cover.

STUDY AREA

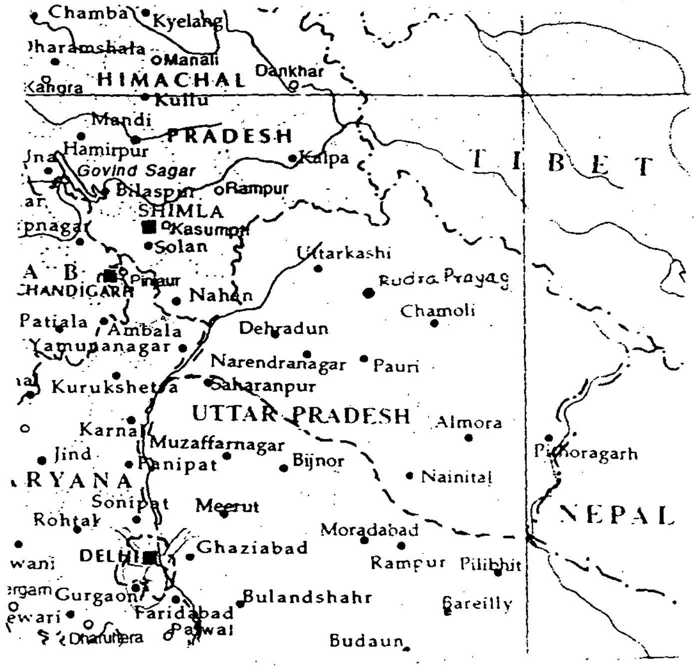
A cluster of three contiguous village viz. *Deowar, Nala* and *NarayanKoti* were chosen for study from an agriculture rich pocket of Garhwal Himalaya. The area falls in Rudraprayag district of one of the recently formed state Uttranchal in norhtern India. Geographically the area represents mid-altitude mountain system (Average elevation 1200-1700m from MSL, 79°10' E longitude, 30°31' N latitude)

2.1 General Description of the Landscape and the Communities

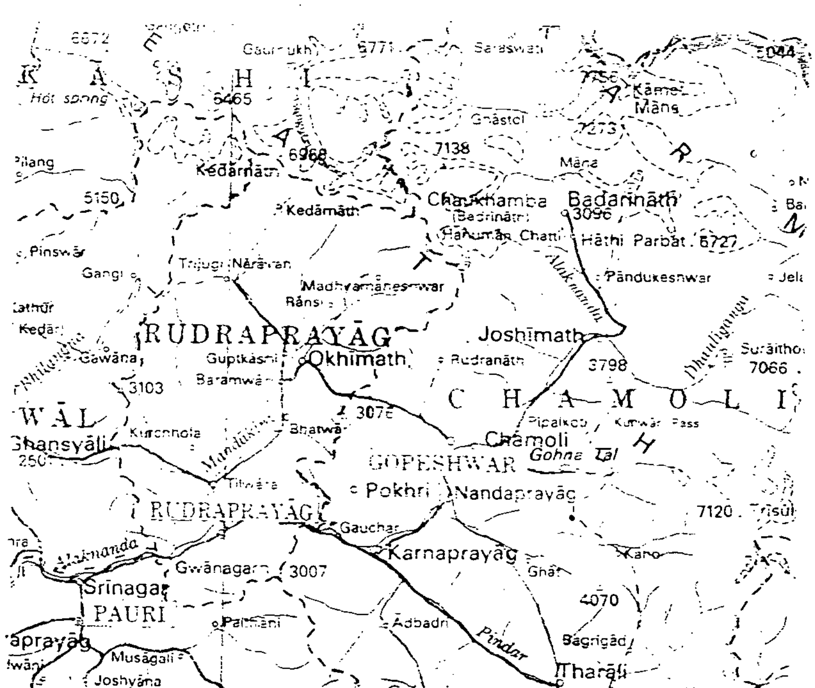
These villages lie adjacent (1 to 4 km apart) to a small town Guptkashi, which is situated at a distance of 180km from the nearest railway station Rishikesh, 45km from the district headquarter Rudraprayag and 17km from block office Ukhimath. Guptkashi is a popular hill-station on the Rishikesh Kedarnath highway with a population of 5000 approximately. (District census handbook,1991). The town cherishes substantial tourism prospects during summer months when thousands of pilgrims and tourists make their way to Kedarnath and Triyuginarayan, two famous Hindu pilgrimages. A major portion of rural population from adjacent villages avail the employment opportunities created by tourism at Guptakashi and Kedarnath.

The villages belong to *patwari* area of Guptkashi, which includes 12 other villages. Devshal, Khumera, Kothyara, Hyun and Jurani are the neighbor villages, which share many features, with the study villages. These villages in bulk from an extensive agricultural landscape terraced along countours, which make a visual mosaic of alternating fallow, and cropped sectors in winter.

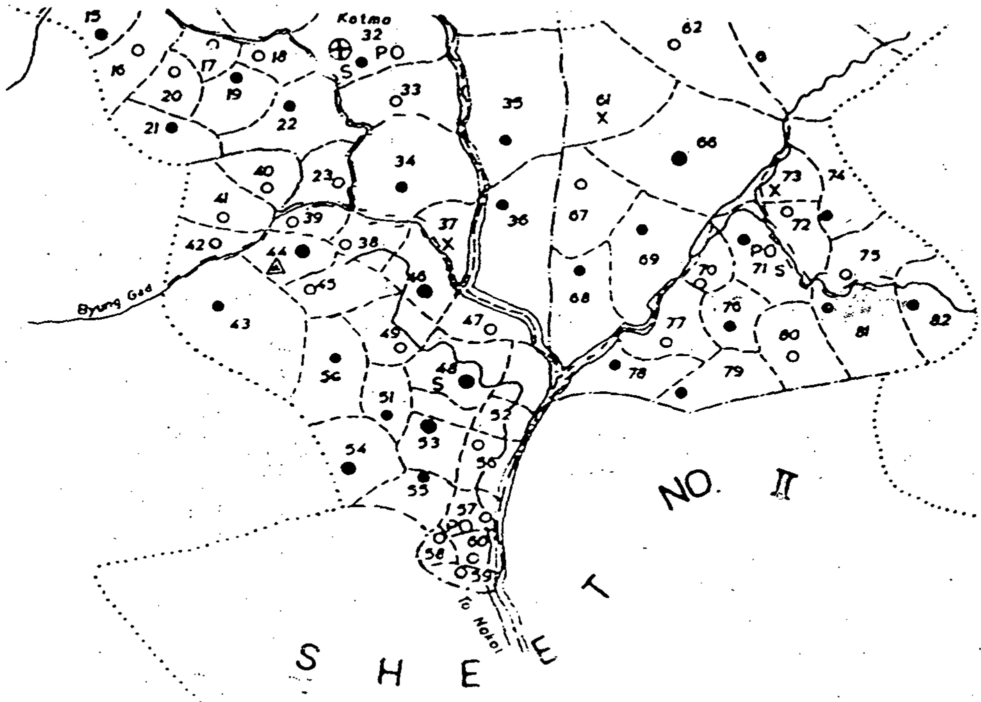
Major part of the landscape is inclined towards east with an average slope of 30°-40°, which terminates into right bank of the river Mandakini. Land in Deowar is mostly inclined toward E to NE and exposed to snow peaks of high mountains. Exposure of Chaukhambha (5600m) is reported to affect crop yield substantially by promoting husk part with the agronomic yield. Nala and Narayankoti are oriented



Location of Uttranchal



Location of Rudraprayag District.



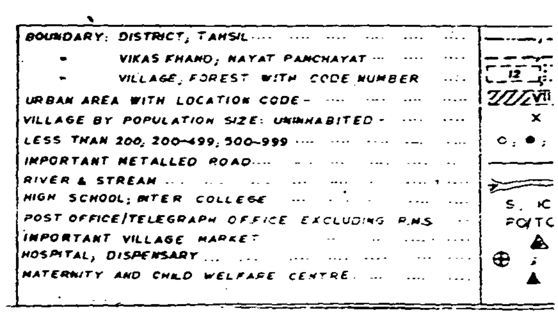
Location of Study area in Tahsil Map of Ukhimath.

46. Narayankoti

48. Nala

53. Guptkashi.

54. Deowar



towards SE and E respectively for the major part of the village. Both villages are protected from exposure of higher peaks by a veiling mountain in front of these.

Among the three villages, Deowar is situated at heighest elevation (1750m), while Nala and Narayankoti shares the same elevation (1380m). The latter two villages are separated by a mountain ridge and slightly differ in aspect and slope.

A total number of 4 perennial and 12 seasonal streams and 5 spring traverse through the villages. Narayankoti claims maximum number. Due to availability of running water for 3-4 months, Nayarankoti, represent irrigation potential for an area of 4.2 ha (approx.) as additional feature besides rain-fed agriculture, which constitute 95% of cultivated land. Agriculture in Nala and Deowar are totally rain-fed.

For Nala, wide plots with fairly gentle slope form approximately 60% of the cultivated land. These plots, despite scarcity of water, maintain soil moisture and are reported to be highly fertile, compared to other landmass in the landscape. Doewar and Narayankoti show medium sized terrace field in general.

Additional irrigation opportunity for Narayankoti is however very unevenly distributed. For farmers with bigger plots of irrigated land cultivates vegetable especially *cabbage* and *onion* on commercial scale while more than 60% household either do not have irrigated plots or have only insignificant piece of irrigated land, producing too little to be exported. Based upon this, Narayankoti can be divided into two communities:

1. One who cultivate vegetable on irrigated land with plot size more than one *Nali*, which can produce vegetable worth more than Rs. 3000, an expected monthly expenditure for average household in the area (average monthly expenditure was assessed by talking to different households). And
2. Other who practices only rain-fed agriculture in Narayankoti

There is no considerable reason to make such typologies for Deowar and Nala where all villagers practice only rain-fed agriculture.

Thus with a view to study land use types and dynamics in the landscape four communities can be specified, viz. two from Narayankoti and one each form Deowar and Nala.

2.2 Geology

The geology of the region shows rock formations dating back Mesozoic period (when Himalayas were elevated from Tethys sea). The region lies in tectonic zone with folds and overthrust mountain chains, marked by complex folds, reverse faults, overthrust and nappes of great dimensions, all these as well as frequent earthquakes of varying intensity make a sense that the region is still unstable. Chaukhambha peaks is visible from the study site, appears to be crater of extinct volcano. The direction of folding in these mountain masses is generally north to south. Major rocks reported for the region are gneisses, limestone, phyllites, quartzites, sericite-biotite schists and slates.

2.3 Climate

Climatic conditions differ always with altitude. The winter season is from mid-November to March. As the region is situated on southern slopes of outer Himalayas, monsoon current can enter through valley. During the period June to September the region receives about 70 to 80 % of the annual rainfall and about 10 to 15 % of precipitation occurs during winter months. Considering the period from 1901 to 1950 the total number of years with rainfall less than 80% of the normal was 6 (Ukhimath) in this area. Average annual rainfall of this region is 1000 to 2000mm. The mean maximum and minimum temperatures are 27° and 2° C respectively. The relative humidity is high during monsoon months generally exceeding 70% on the average, and even drops to 35% in pre-monsoon afternoons (District Gazetteer, Chamoli-Garhwal, 1981).

2.4 Vegetation

The area represents sub-tropical to temperate forest. Quercus semecarpifolia, Rhododendron arboreum, Alnus nepalensis, Myrica esculenta, Pyrus pashia, Juglans regia, Pinus roxburghii,and Toona celiata, are common tree species in forest.

2.5 The Agricultural System

Farmers in the village cultivate several different staple crops and many varieties of each of them. Wheat, rice and koda (finger millet) are agronomically and dietarily the most important crops of the region. Among others a number of pulses, millets, spices and vegetables are grown.

Almost all agriculture is destined for subsistence consumption. Little of the produce grown is sold or leaves the community. A portion is set aside as future seed and a varying amount as buffer. As subsistence producers, farmers avoid the double hazard inherent in cash crop production in which farmer are first exposed to the risk of poor yield and/or low market prices for their produce, and are placed at risk if price rises for staple food.

Fields cultivated by community members are scattered over the steep altitudinal gradient of the surrounding landscape. The most distant fields of households in general are located at about 2 km from settlement.Families plant, on average, 12-13 fields each year. There is a considerable range from the minimum to the maximum number planted by any individual family. The average agricultural plot is quite small, roughly 300 m^2.

Most of the land used by families is acquired through inheritance. Men and women inherit land primarily from their parents and less commonly from other relatives. Inheritance is not the only means of acquiring land, however. Some times land is purchased. Such purchases are usually made from elderly community members who are without heirs. In addition fields are rented or borrowed. Rental and purchase opportunities could work to effect consolidation of landholdings if farmers sought it. That field scattering persists suggests that farmers perceive some benefit from it.

Most agriculture is organized in sectorial fallowing systems. Fields are used according to a set rotation of crop use and fallow, called *sari* is the primary organizing concept for thinking about, talking about, and doing agriculture.

A *sari* is composed of contiguous sectors of land, each comprised of the individual fields of community members. Within each of the sectors all fields are either cropped or left fallow at the same time. During the years when a sector is planted, all the individual fields in it are planted with the same corps. The number of sectors is equal to the number of years of the rotation (i.e. fallow years + cropping years = number of sectors). During cropping years, each household has access and usufruct rights to its own lands within that sector, although community-level decisions dictate cropping choices and planting dates. In the years when a sector lies fallow, all households have access and rights to all lands within the sector, to graze animals, collect dung, and so on.

The community coordinates agricultural activities in the *saris*. Sectorial fallowing, among other functions, mediates the sometimes-competing demands of pastoralism and agriculture. Planting dates must be agreed upon so that villagers will know when to remove their animals from the sector. This coordination of fallow periods provides land near the community that can be grazed without fear of causing crop damage. Animals grazing on the stubble of recently harvested fields and in fallowed sectors deposit during that fertilizes the soil.

An additional advantage of sectorial fallowing is that it is an effective way to manage fragile high altitude lands. Soils are depleted of macronutrients during cropping years and require lengthy periods of regeneration. In high-altitude regions the decomposition of organic materials- and therefore, replenishment of soil nutrients- is retarded. Long periods when fields lie fallow may also be critical in ridding the soil of pests and diseases, especially those that attack the all important crops.

METHODOLOGY

3.1 Comparative Risk Assessment

Methods adopted for this part of study are as:

3.1.1 Research Design

The study is designed to execute following exercises.

(1) Confirmation of temporal variation in crop yield (wheat) across different field of:

(a) Different parcels

(b) Same parcel.

(2) Confirmation of spatial variation in crop yield (paddy/wheat) (between vegetable grower and conventional peasant) across different field fields of:

(a) Distant parcel.

(b) Same parcel.

Statistical analysis of observation to reach the inference

3.1.2 The field study

The study was carried out between September 2001 and April 2002 in Narayankoti village. It incorporates following steps:

1. ***Base-line information about the environmental setting:*** Information on geographical characteristics of the site, climate, land classification, land use, land cover, demography, livestock, different resource bases economy and socio-cultural aspects were collected through various sources that include village assembly, block development office, forest department, revenue department, census office and local co-operative societies as formal channel; and village in general, personnel from different department who are informally associated to the site, shopkeepers in village and market and person representing certain informal institution as informal channel.

2. ***Selection of study crop and yield estimation (specification):*** As per requirement of research design, wheat was chosen for study. This is the major crop of the region for *Rabi* season. Farmer's reference was the main source of observation for estimating yield.
   To decode their reference conventional units of production measurements (i.e. *Bori, Maund, Doon, Patha*) were converted to equivalent metric units (i.e. Quintal, kg). While referring area of fields, Nali is observed as common unit, used by people as revenue department (1 Nali = 200 m^2; 1 ha = 50.003 Nali) in the region. Crop yields were calculated as kg / Nali for comparision purpose and Quintal / ha for absolute reference.
   Besides farmer reference, yield for wheat was also confirmed by self harvest method, 5 quadrates each of 1x1 m^2 size were laid randomly in the sampled field and harvested a few days before the actual harvest by the farmer community. The grain is sun-dried for two consecutive days and weighed to calculate crop yield.

3. ***Inventorization and characterization of field, land parcel and concerned household:*** Thirty-two household were surveyed from the village out of these 14 household cultivated vegetable commercially while conventional agriculture was the mainstay of other 18 farmers. The reason to survey slightly more number of household from conventional farmer community is to facilitate comparison as t he latter represent a larger population, more field per parcel throughout the village. For all surveyed household an inventory was made to describe the distribution of landholding across different parcel. A detailed account was pursued for the fields, which fall under the study crop (i.e. wheat *sari*) in current year. Area, crop combination, number of agroforestry trees, field width were noted as field characterization while distance from settlement, aspect relative elevation were noticed no parcel characterization. Besides their household characteristic, like number of family member, manpower, livestock composition, and economic status were also inquired of.
   Sample for next two-step would be chosen with the help of this inventory.

4. ***Confirmation of temporal variations in crop yield*:** For this exercise fields and land parcels were selected from the inventory based upon following:

(a) ***Parcel characteristics.*** They should represent maximum heterogeneity with in the village with respect to distance from settlement relative elevation respect and some variation crop in a yield for along the parcel exercise the sampled parcel should be large Land distant substantial in distance for settlement for across pared exercise.

(b) ***Field characteristics***. The same crop should have been cultivated in all the sampled field current year (n) as well as in the penultimate year (n-2). There should be least variations in certain field parameters (e.g. width and geometry), which interfere in estimation of actual cultivated area. It was ensured that between the last two years these fields have not been subjected to any major change in soil composition, mechanical perturbation except routine farm activities. In along the parcel exercise, all the fields in the parcel should share parcel characteristics

(c) ***Household characteristic:*** Household associated to sampled field should be able to recall crop yields for the previous harvest and to report precisely yield for the current season. The household must not be subjected to major changes for the period with respect to manpower, livestock composition, economic status, and household enterprises. No consideration was entertained whether sampled household cultivate vegetable or practice conventional agriculture. All households should be resident of main settlement in the village. To minimize errors associated with recalling, confirmation of temporal variation in crop yield was made only for wheat crop as it was possible to observe its harvesting for the current season

The exercise was executed along two axes:

I. ***Confirmation of temporal variation in yield across different parcels:*** Parcels were identified from the inventory. From each parcel single field was selected which was most precisely reported for amount of crop for production and values for each were noted for further computation confirmation.

II. ***Temporal variation in yield along same parcel:*** Two largest parcels were identified one was far from the settlement while other was substantially near to the same as per availability of fields under designed criteria, 7 and 8 fields were selected from distant and proximate parcel respectively. One household in each parcel owned no two fields. Amount of crop produced and field area was noted for each field for further computation.

1. ***Confirmation of spatial variation in yield***: To compare crop yield between vegetable cultivator and conventional farmer, land parcel and fields were selected from inventory.
   (a) Parcel characteristic – The parcel must be large enough to accommodate substantial number of fields from both farmer communities. They should differ in distance for the settlement.
   (b) Field characteristics – Same crop should have been cultivated on all the fields in each parcel for current season. There should be least variation in the field characteristics (e.g. area width, geometry), which interfere in the assessment of field area actually cultivated. All fields in one parcel should share parcel characteristics to the possible extent.
   (c) Household characteristics – All households should be resident of main settlement so that distance perspective can be generalized. Desirably they should resemble in per capita landholding.

As per availability under designed criteria two large parcels were identified viz. distant and proximate. 7 fields from distant parcel were selected for each former community. Similarly 9 fields from proximate parcel were selected from the each community. Amount of crop produced in current season and area were noted for each field for further computation.

Crop yield were also confirmed by self-harvest method mentioned earlier for the each field, selected for sampling.

3.1.3 Laboratory work

Wheat grain harvested from the field was sun-dried and weighed in the laboratory up to least count of 1 gm.

3.1.4 Data analysis

Statistical tests applied to different observation are:

1. ANOVA to examine difference in mean yield fluctuations since last harvest for:
   (a) Fields of different parcels
   (b) Different fields of the same parcel: again for
       1-distant parcel
       2-proximate parcel
2. ANOVA to examine difference in mean yield for two farmers community for
   (a) Distant parcel
   (b) Proximate parcel

   The reported and self-harvested values of crop yield were dealt separately.
3. Miscellaneous: Correlation between the reported and self harvested values of crop yield.

3.2 Comparative studies of land use – land cover

Methods adopted for this part of study are as:

An inventory was made at household level for 6 households from each of the four farmer communities. Among structural parameters, information was obtained for:

1. Household characteristics including human population manpower, economic status, livestock and landholding size. Livestock size was counted in Livestock Standard Unit (Following Sen. et al., 1978.)
2. Cropping pattern and area under different crops.
3. Home-garden composition.
4. Density of agro-forestry trees in fields.
5. Density of concerned community forest and common reserved forest.

Among functional parameter, households were inquired for:

6. Agronomic yield of major crops.
7. Consumption pattern of the household for different agricultural commodities.
8. Degree of self-reliance

Information on various parameters was collected following the methods described by Mishra and Ramakrishnan (1981), Pandey and Singh (1984) and Maikhuri (1991), as below;

1. Household characteristics: the sampled households were inquired for the information
2. Cropping pattern and area under different crops: Households were inquired as well as field examinations were made.
3. Home garden composition: Area of all home garden was precisely observed up to least count of One *mutthi* (12.5m) estimated and trees of different special were counted (with a height more than 6 fts.). Trees were categorized into fruit & fodder classes.
4. Agro forestry trees: 2 fields from each household were examined for tree count and area was precisely noted, based upon farmer's reference.
5. Density of concerned community forest and reserve forest: 10 quadrātes each of 10x10m were laid randomly (trees with a height more than 10 fts.).
6. Agronomic yields for the major crops: people's reference was the main source of yield assessment. However harvesting was also observed partially for confirmation. Villagers reported agronomic yield in conventional units like *sacks* (average being 80 kg), *maunds* (average being 40 kg), *Doom* (average being 32kg), *path* (average being 2kg) and *mana* (average being 0.5 kg). State revenue department had measured area under crops fields, which are known to the in terms of *naali* (200m, 1ha = 50.003m) and *mutthi* (1 *mutthi* = 1/16, *nali* =12.5 m), Pandey and Singh (1984) and Maikhuri (1991).
7. Consumption pattern: Households were sampled three times, between September 2001 to April 2002. Each time, consumption of different cereals, pulses and oilseeds were noticed for a period of 15 days. The households were asked to make an account of consumption 15 days before the observation (Following, Mahajan *et. al.*1997).

8. Assessment of self-reliance: It was estimated as the ratio of the production to annual consumption for a particular crop. Self reliance in economic terms were also calculated as the ratio of monetary value of total production to monetary value of annual consumption of all the crops accounted

Assessment of cropped area (acreage) was made for all major crops while that of consumption and self-reliance were made for wheat, rice, *mandua* while pulses, oilseeds, vegetable, spices and fruits were escaped.

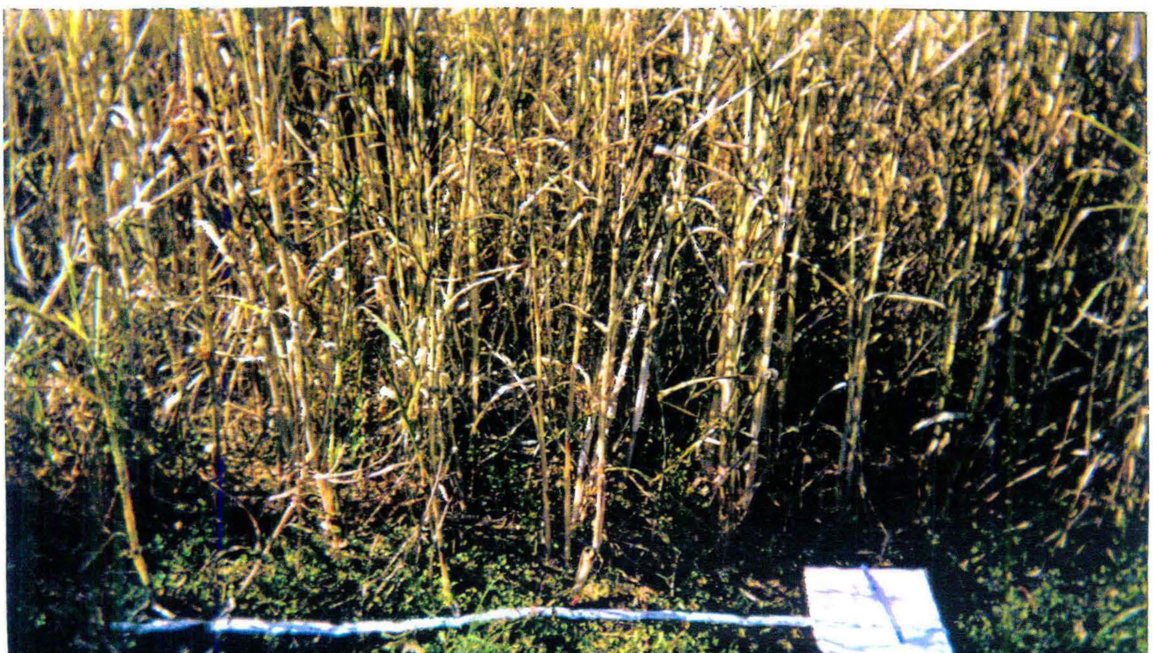
Proximate fields of Narayankoti with rabi crop.
Note the vegetable cultivation, occupying wider fields.

Distant fields of Narayankoti with rabi crop:
Marginal, less accessible, steeply sloped land in the vicinity of community forest.

Vegetable farms of Narayankoti: Youngsters are better informant.

Home-gardens in Narayankoti: Source of year round vegetables for households.

Mixed kharif crop in Nala fields:
Fairly mild slope and excellent terrace are remarkable.



Rarely observed monoculture of Koda (*Eleusine coracana*):
The crop for which the landscape claim self-sufficiency.

Wheat fields of Deowar: Healthiest crop in the landscape
but not enough to meet annual requirement.

Clustered settlements of Deowar with low density of trees in fields:
Way to adapt with high altitudes.

RESULTS

4.1 Comparative Risk Assessment

The study came out with following results for various parameters:

4.1.1 Temporal fluctuation in Yield:

One factor ANOVA was executed to compare mean value of yield fluctuations for 3 sets of cropped fields viz. (a) Fields distributed along the distant parcels, (b) those distributed along the proximate parcel and (c) those distributed across different scattered parcels.

Test results (table-12) show that:

- Mean value of fluctuation is highest for the fields distributed along distant parcel.
- Variance for yield fluctuation is highest for the fields distributed across different scattered parcels.
- Among the three sets, the mean field fluctuation differs at 11% level of significance (almost significant at 10%).
- Between first and second sets, mean yield fluctuation differ at 4% level of significance (highly significant at 5 and 10% levels)
- Between second and third sets, mean yield fluctuation differ at 24% level (less significant) and
- Between first and third sets, mean yield fluctuation differ at 53% level (very less significant).

4.1.2 Spatial variation in the Yield:

Two factors ANOVA was executed to analyze variation in crop yield for wheat. Variations were considered due to difference in (a) communities i.e. nature of farmer community whether it cultivates vegetables or practices conventional agriculture and (b) sampled field themselves. In ANOVA exercise the two are termed as column and rows. Inferences were made by referring, column average, F-value at 5% level of significance (α= 0.05) and P-values (which represent exact level of significance). The Four designed exercises came out with following results:

A. For distant parcel when self harvested for yield estimation (table-14)

Between Communities-

- Mean crop-yield is higher for conventional farmers.
- Difference of mean is highly significant at α= 0.05 (not mentioned hence forth).
- Exact level of significance is 0.7%.

Between sampled fields

- Difference of mean is not significant.
- Exact level of significance is 70%.

B. For distant parcel when yield was confirmed by people report.(table-15)

Between Communities-

- Mean crop-yield is higher for conventional farmers.
- Difference of mean is not significant.
- Exact level of significance is 27%.

Between sampled fields

- Difference of mean is not significant.
- Exact level of significance is 56%.

C. For proximate parcel when self harvested for yield estimation.(table-16)

Between Communities-

- Mean crop-yield is almost equal for both farmer communities.
- Difference of mean is not significant.
- Exact level of significance is 90%.

Between sampled fields

- Difference of mean is not significant.
- Exact level of significance is 37%.

D. For proximate parcel when yield was confirmed by people report.(table17)

Between Communities-

- Mean crop-yield is higher for vegetable cultivators.
- Difference of mean is not significant.
- Exact level of significance is 20%.

Between sampled fields

- Difference of mean is not significant.
- Exact level of significance is 56%.

4.1.3 Correlation between reported yield and self-harvested yield.

Results shows positive correlation for all designed exercises but the degree of correlation varies as (table-18)

A. ***For distant parcel***

For vegetable cultivator

- Data are mildly correlated (r=0.49).

For conventional farmers

- Data are poorly correlated (r=0.26).

B. ***For proximate parcel***

For vegetable cultivator

- Data are strongly correlated (r=0.94).

For conventional farmers

- Data are poorly correlated (r=0.33).

Following inferences can be reached out of the statistical results:

- Since the variance, in one factor ANOVA exercise, is highest for the third set of fields (out of the three sets), it indicates that the variations in yield fluctuation across the parcels is higher than that observed within same parcel. Conversely it implies that yield fluctuations are localized in nature and differ between parcels or patches, in the study site. These findings claims that field scattering as a means of risk management would be applicable in the context, which was the first of the designed objective of current study.
- For distant parcel when crop yields were confirmed by self-harvest method, vegetable cultivator and conventional farmers differ significantly (α= 0.05) with respect to crop (wheat) yield. Average yield of crop was found higher for conventional farmers. The finding supports partially the second part of the designed objective i.e. vegetable cultivator fail to cultivate their distant fields as efficiently as conventional framers do.
- When people reported crop yield, the average yield were found higher for conventional farmers but the difference was not significant (at α=0.05).

- For proximate parcel when people reported crop yield, the average yield were found higher for vegetable cultivator. However, difference is not significant.
- For the same proximate parcel when crop yields were confirmed by self-harvest, the average yields were almost equal with no significant difference (at $\alpha=0.05$). These findings support the hypothesis but very feebly.
- The difference in decision of two approach of yield estimate (i.e. reported by people and by self harvest) is further explained in terms of correlation coefficient. For distant parcel, as data are poorly correlated, the difference in decision occurred, while in case of proximate parcel yields were strongly correlated between two approaches and indicate uniformity of decision.

4.2 Comparative studies of land use – land cover

4.2.1 Household Characteristics (Table-2).

Vegetable growers of Narayankoti (i.e. Nvg.) do not differ significantly from conventional farmers of Narayankoti (i.e. Nkn), Nala (i.e. Nla) and Deower (i.e. Deo) for average number of persons and working manpower per household. Deo represents slightly higher number of livestock standard units compared to other threes.

4.2.2 Cropping Pattern and Area under different Crop/Crop combinations

Kharif season: (table-8 & fig.1)

Nvg and Nal show lesser area under monoculture compared to other two communities. Monoculture in the season is mainly represented by paddy crop. Nvg shows substantial area under pulses compared to other communities who do not have irrigated land. Deo differs from others as it shows additional area under Amaranthus and millets in monoculture. A total number of 8 crops are cultivated by Nvg, while Nkn cultivate only 5, Deo 7 and Nal 4.

Under mixed cropping 2-crop and 3- crop combination(s) claim apparently equal area for Nvg while for Deo 3-crop combination(s) occupy very small proportion of land. A total number of 5 combinations are cultivated under 2-crop combinations by Nvg. The numbers are slightly more for Nkn and Nal. For all communities crop combination(s) of *Koda* and pulse dominate in 2-crop combination(s) while *Koda* pulse along with *Tor* in 3- crop combination. Only Nvg and Nal show multiple crop-combination.

In kharif season a small area for sampled households was observed under fallowing, for all communities. It is slightly higher for Deo.

Rabi season: (table-9 & fig.2)
Among the four communities, Deo shows highest value for area under monoculture while, Nal the least. For Nvg cabbage, potato and onion all occupy considerable area while, for Deo wheat and potato occupies the same status under monoculture. Other two communities show miscellaneous values. The number of crops cultivated under monoculture is highest (6) for Nvg compared to others. The additional crops in case of Nvg are those, which are grown in irrigated land.

For 2-crop combinations Deo shows highest value while, Nvg the least. Different combinations are miscellaneously distributed among the communities and no one combination can be claimed to be the most popular combination for all villages. Wheat and mustard are however observed more commonly. Despite least acreage under 2-crop combination(s), Nvg shows highest number of crop combination(s) for the same.

Among 3-crop combination(s), wheat lentil and mustard is observed as most popular combination for Nvg, Nkn and Nal.

Fallow land occupies a substantial part of the total land for the season. However Nvg show least area under fallowing compared to others.

A total number of 30-crop/ combination(s) were observed in kharif season while, 25 in rabi season for all the communities. Since almost half of the land undergoes fallowing during rabi season, crop combination density would be higher for rabi season than for kharif.

4.2.3 **Home garden attributes** (table-5)

Mean per household availability of home garden for all communities is 0.36 nali, which is hghest for Deo and least for Nal. With respect to number of malta trees per household, Nal claims first rank followed by Nvg and Nkn. Similar trend was observed for fruit trees in their share in total tree observed in home-garden. It reaches up to 77% for Nal and 60% for Nvg. Density of trees in home-gardens is highest for Nal (818/ha), followed by Nkn (733/ha), Nvg (460) and Deo (338/ha). *Malta* is most frequent as well as most populated species for all communities except Deo. *Timla* and *Kharik* are observed as second most-populated and frequent species for the same three communities. Deo on other hand represent different species. Nvg shows less density for home garden trees than Nal and Nkn.

4.2.4 **Agroforestry attributes** (table-6)

Average size of plots for all communities is 1.38 nali, which does not shows much variation among the communities. Fruit trees occupy only 14% shares with respect to the number of all trees in these fields. Density is highest for Nvg followed by Nkn, Deo and Nal. *Chinchri, Thelku* and *Timla* are most populated as well as frequent species in these fields for Nvg, Nkn and Nal. Deo on other hand show occurrence of *Akhrot and Anyar* besides *Chinchri.*

High density of agroforestry tree in case of Nvg indicate increased preference of the community towards fodder trees as a measure to compensate fodder requirement that is otherwise supplied for as byproduct with staple crop. It indicates that Nvg communities might be facing certain extent of decrease in staple crop production and associated byproducts. Moreover increase farming and manure requirement with vegetable farmer associated increase in demand of fodder are likely reason.

4.2.5 **Forest Attributes** (table-7)

Among the community forests tree density is highest for Nkn/Nvg (750/ha) followed by Deowar (720/ha), Nal (620/ha). Banj (*Quercus*) and Burans (*Rhododendron*) are the commonest species. Density of reserve forest is the lowest (520/ha) of all. Species area ratio is highest for Deo and Nkn/Nvg. Similarly species/thousand individual ratio is highest for reserve forest. While community forests are adjacent to the villages, reserve forest spread at hilltops at a distance of 4km approximately from village-cluster.

4.2.6 **Yield of major crop** (table-10 & fig.3)

Comparative study of yield suggests highest yield of rice for Nkn, wheat for Deo and *Koda* for Nal. Per household production of rice is highest for Nkn, wheat for Deo and *Koda* for Nal. The similarity of the production and yield suggest that there is no significant differencet with respect to area under these crops among the communities.

4.2.7 **Consumption pattern of household for different cereal crops** (table-11 & fig.4)

Per household consumption range from 305-480 kg for rice, 180-281 kg for wheat and 204-391 for Koda per year for different communities. There is miscellaneous pattern in the annual consumption for different cereals. Consumption ratio of different crops varies apparently for different communities.

4.2.8 **Degree of self-reliancy** (table-11 & fig.5)

It is observed as proportion of surplus or deficit in production with respect to annual requirement (consumption). Except rice for Deo, Nal and Nvg; and wheat for Nvg other show more or less amount of surplus production in current year.Surplus is highest for Koda with Nal followed by Nkn.

DISCUSSION

Among various specificities associated with mountains, heterogeneity along spatial and temporal dimensions is one dominant feature, which manifests itself in spectacular variation among natural, semi-natural and anthropogenic features. These specificities result in uncertainty of production function along various resource bases and compatible adaptive mechanisms.

Geophysical factors such as altitude, slope, aspect, soil moisture, and receipt of solar radiation can vary sharply within small areas in mountains (Sarmiento, 1986). These factors are compounded by localized precipitation and frosts. As a result, agro ecological conditions are patchily distributed and irregularly timed. This heterogeneity may profoundly alter the growing environment for the crops that provide the subsistence base for peasant households in mountain zones. The quality and quantity of agricultural production varies dramatically from place to place and from one year to another.

This presents the problem of how farmers can minimize the probability of production shortfalls. Because of environmental unpredictability, each year farmers face the risk of failing to provide their own subsistence needs. Andeanists (Guillet, 1981a; Figueroa, 1984; Orlove and Guillet, 1985; Browman, 1987) and other mountain specialists (Weinberg, 1972; Friedl, 1974; Netting, 1981) have suggested that one way farmers may reduce this risk is by planting several dispersed agricultural fields rather than a single consolidated one, because the pooled harvest of the scattered fields provides greater security. This is an agro-ecological analog of the old admonishment not to "put all your eggs in one basket." Others see this practice as an undesirable result of several possible origins: farmers blindly clinging to tradition, inheritance patterns that continually fragment land, natural topography dividing farms or some other social or natural cause (Binns, 1950; Smith, 1959; De Vries. 1974). Critics of field scattering emphasize the inefficiency of traveling and transporting materials between distant fields. In both cases, proponents and detractors have made judgments about field scattering with little empirical evidence to substantiate their claims (King and Burton, 1982; Bentley, 1987)

With a view to compare risk management attributes between commercial vegetable cultivators and conventional farmers, the study tests two hypotheses:

The first hypothesis was meant to determine whether field scattering as described by Goland (1993) as means of agriculture risk management, in Andean context would be equally applicable in Himalayan context and particularly for the landscape under study.

One of the fundamental assumptions of this model (Goland, 1993, Mc Closkey, 1975, 1976) specifies the condition for its applicability to a landscape, as if the fluctuations (particularly the unexplained variance) in yield between fields are not strongly positively correlated. A harvest, which pools the yield of several fields, should reduce variance relative to that would be experienced if families relied on a single consolidated field.

Hence testing the assumption in any context would require information on yield fluctuation along time series so as to detect the possibility of correlation between yield fluctuation of two different fields of scattered landholdings.

In a short study schedule, the information or crop yield could only be obtained by farmer's reference. There are studies that to show that peoples reference might be an efficient tool to ascertain parameters like yield (Pandey and Singh, 1984), but recalling yields for past year is more error prone even with farmers reference, as farmer usually keep an informal account of pooled yield of the entire land-holding rather than of a single field or parcel of land (Shriar, 2000).

As elsewhere in most of the mountainous system (Brush, 1977, Ramakrishnan, 1992) agriculture in Himalayan context observe sectoral fallowing and scheduled crop rotation (Semwal, Maikhuri, 1996) in which a fields in general are subjected to change in crop composition by alternate year. Hence, to seek a particular crop on a field for two calendar years would require examination of the crop, in current and penultimate year. Due to these constrains the number of households those could be taken as samples, remained very small, in present context.

To facilitate the test within available information base a hypothesis has been designed, parallel to as proposed by Goland (1993). It holds that if the fluctuations were more localized in nature, they would not show strong correlation between parcels; and hence would act as means of risk management.

So, instead of going for testing correlation between yield fluctuations along time series, the study can be focused on enquiring spatial distribution of occurrence of fluctuation in crop yield.

The study compared fluctuations in yield (i) across the parcel and (ii) along a single parcel of land. Occurrence of more variation in yield fluctuation were observed for the fields which were located at different parcels, compared to those which were located at the single parcel. These observations make a sense that variation in field fluctuation across scattered parcels would be high due to the fluctuations being more localized rather than homogeneously distributed throughout the landscape.

As crop yield in any plot is governed by numerous factors (Caraco, 1980), so the fluctuation in yield would be accounted due to change in these factors. Here fluctuation in crop yield is taken as unexplained variance [which is not explained by known factor governing crop yield (Goland, 1993)].

In the context of study area localized frost, patchy precipitation, disease or the similar factors results in localized occurrence of fluctuation in the landscape.

Studies on yield fluctuation in Andes, South America, emphasizes that mountain heterogeneity on form of patchy distributed and irregularly timed agroecological condition alter the growing environment substantially (Guillet, 1981; Browman, 1987).

The fluctuation in crop yield based on farmers' reference cannot be totally attributed to uncertain phenomena like frost; precipitation or disease. Change in factors (which are fairly explained) governing the crop is likely to interfere detection of fluctuation, which are unexplained in most of the cases. The two remain inseparable until an additional analysis is performed to deal them separately.

Goland (1993) used multiple regression models to trace out the factor, which govern variance in crop yield. He treated seed density, labour and fertilizer inputs, altitude, date of planting and fumigation as known factors in multiple regression but even despite the modest success of regression models, much of the variance in yield cannot be accounted for by those factors imported into analysis. What the model fail to account was important for risk analysis.

Though these much factor have not been taken into account while estimating fluctuations, but to overcome the possibility of interference by these factors, it was ensured during sampling that the sampled field and concerned household must have not been subject to change with respect to these factors for the two cropping years. Nevertheless inadequacy of household survey to detect those factors with precision cannot be desired.

The second hypothesis was tested to determine whether vegetable cultivators of the region cultivate these scattered landholdings as efficiently as conventional farmers do. There arise few questions: firstly whether efficient use of scattered landholdings means compatibility of the farmers with scattered nature of their landholdings. And secondly how to compare the efficiency of farmer's use of the scattered parcel and thirdly what should be the exact measure of scatteredness.

Despite a prospect of debate, present study assume that efficiency of land-use as indicator of compatibility, crop yield as indicator of efficiency of resource use and distance from house as measure of scatteredness can serve the purpuse (Bonner, 1983).

Based upon observation of difference in yield across different parcels as the same along the same parcel make a sense that within a parcel there is less variance in crop yield due to natural factor. And a difference of crop yield would indicate possibility of difference in factors, which are attributes of the concerned household rather than plot it-self. Household attributes like manpower, family enterprises, livestock affects not only the yield of crop in the farm but also the differential preference forwards differential preference forwards different crops and land use pattern (Kristensen et al. 2001). Hence with a view to analyse compatibility of household towards scattered landholdings, crop yield for those household can be taken as indicator of it.

Two modes of yield estimation have been used. The success with the self-harvest method would depend upon the representative ness of the quadrats under study. 5 quadrats, of 1x1m size, per field (with average size of 1 Nali) will represent only 1/40th part of the field's agronomy that is inadequate until selection of the quadrates is very representative. On the other hand the drawbacks with relying upon people report for yield estimation is the lack of precision is most of the cases.

Correlation coefficient between yield calculated from two channels differ for the two communities as well as from distant patch to proximate patch. Between the two communities the higher correlation is observed for vegetable cultivators while lowest correlation coefficient is observed for conventional farmer in distant parcel.

correlation coefficient is observed for conventional farmer in distant parcel. The difference might be due to anomalies in assessment of cultivated area precisely within a field. Farmers report was the source of assessing the area of the fields, which are actually measured by revenue department dating back some 40 years. There are fair chances of change in geometry and actual areas of the field due to a number of human and climatic perturbations since then. So precision of yield value reported by farmers would suffer these changes.

Land use land cover studies, on the other hand make a miscellaneous impressive, so far trends associated with the comparison on conventional farmers to commercial vegetable cultivation is concerned. We are difference between the four communities with respect to household characteristics, cropping pattern, area under cultivation, home garden composition, agro forestry attributes, production and consumption patterns. However there is no lineare trends as the sampled communities were taken randomly. But a few observations are still remarkable.

The number of crop/combination for Nvg is higher under monocropping system compared to other communities. However additional crops are vegetables or those which are grown in irrigated land .

There are studies which holds that rain fed agriculture sustain more crop diversity in form of mixed cropping compared to irrigated agriculture. (Semwal and Maikhuri, 1996) Present study differ from these slightly as the number of crops is even higher in irrigated patch.

Similarly higher number of agro forestry trees in fields of Nvg indicated compensatory strategy to fulfill fodder requirement which would we supplied from crop residue for other communities more trees in feeds reduce crop production to some extent. This could be a region for lesser yield of staple crops in case of Nvg.

Lesser yield of these crops manifests itself inform of lesser degree of self reliance i.e. lessor surplus or more deficit after annual consumption, compare to other communities. These studies thus make a sense that the vegetable cultivators are in higher risk of meeting the subsistence level of staple crop production.

CONCLUSION

Increasing concern for monetary economy in subsistence oriented local communities has resulted into a number of land use changes. A shift from conventional agriculture to commercial vegetable cultivation is observed in many pockets of Garhwal Himalaya. Increasing economic penetration, availability of agricultural inputs and access to market prospects enhanced the rate of this changes in that region. Communities, which underwent those changes, cherished better purchasing power and better compared to others.

This shift is however associated with a number of constrains that have been grouped into categories: Biophysical (e.g. land degradation, soil erosion), Socio-economic (e.g. shortening of fallow duration, risk of meeting subsistence requirement of staple crops, limited farm income, shortage of labour supply), and institutional (e.g. poor market infrastructure, exposed to market risk).

Exposure to market risk and risk of failing to maintain subsistence level of staple crop production, are two major concern in the context of Garhwal Himalaya, where the community is frequently subjected to face this risk due to poor transport infrastructure and fragile topography. Conventionally, people living in villages meet their staple food requirements by own production, hence minimize the risk. But few farmers who gave up conventional practices to grow vegetables at commercial level, become prone to these risks.

The risk of meeting subsistence level of staple crop production is related to vegetable cultivation in many ways. Firstly by replacing the staple crop from its previous acreage, secondly by competing with staple crop for various inputs (manure, fertilizer man-power etc.).

One important manifestation of the second aspect, (i.e. competition with staple crop for input) decreased efficiency to cultivate the scattered land holding was observed for the vegetable growing communities. Field scatteredness, a much maligned phenomena, can act as risk management strategy to reduce production variance, provided the yield fluctuations in the region are localized in nature. On this ground one who escape from cultivating the scattered land holding is subjected to yield fluctuation and hence in risk in meeting minimum requirement.

Implication of this risk assessment would however depend upon production potential of the farmer and overall functioning of market structure in that region. However the community would responds towards these uncertainties would rather depend upon its perception towards risk and available options, which are subjected to change.

Table 1. Area under different land categories for the three villages.

Villages-		Deowar		Nala		N Koti	
S.N	Land category	Area(ha)	%	Area(ha)	%	Area(ha)	%
1	Rainfed cultivated	82.58	29.66	81.32	45.56	64.78	38.35
2	Irrigated cultivated	0.00	0.00	0.00	0.00	4.21	2.49
3	Culturable waste	22.64	8.13	2.06	1.15	2.38	1.41
4	Waste due to other reasons	2.49	0.89	12.97	7.27	34.06	20.16
5	Shrub & forest	170.70	61.31	82.15	46.02	63.50	37.59
6	Total area	278.41	100.00	178.50	100.00	168.93	100.00

Source: Revenue Department

Table 2. Socio-economic attributes of the communities.

S.N.	Parameters	Deo	Nal	Nkn	Nvg
1	Landholding/HH(Nali)	27.2	20.0	23.3	19.9
2	No. of land parcels/HH	13.6	8.3	11.6	10.3
3	Average distance of parcels(km)	0.9	0.6	0.7	0.7
4	Avg dist of farthest parcel(km)	2.5	1.6	1.8	1.7
5	Forest availability/HH(Nali)	44.4	20.3	28.0	28.0
6	Distance from reserve forest(km)	2.5	4.5	4.0	4.0
7	No. of persons/HH	5.3	5.6	5.9	5.6
8	Man power/HH	3.2	2.5	3.8	3.4
9	LSU/HH	6.7	3.2	4.4	3.4
10	Cultivated land/LSU(Nali)	4.1	6.2	5.3	5.9
11	Forestland/LSU (Nali)	6.7	6.3	6.4	8.3

Source: Revenue Department

Table 3. Human populatin parameters for different villages.

Villages Census	Population Paramaters	Deowar	Nala	N Koti
1961	Human population	379.00	476.00	400.00
	House-holds	67.00	90.00	73.00
	% increase/ decade	-	-	-
1971	Human population	424.00	700.00	499.00
	House-holds	63.00	144.00	95.00
	% increase/ decade	11.87	47.06	24.75
1981	Human population	500.00	798.00	578.00
	House-holds	100.00	174.00	61.00
	% increase/ decade	17.92	14.00	15.83
1991	Human population	639.00	925.00	685.00
	House-holds	111.00	196.00	143.00
	% increase/ decade	27.80	15.91	18.51
*2001	Human population	762.00	1235.00	820.00
	House-holds	151.00	215.00	163.00
	% increase/ decade	19.25	33.51	19.71

source: District Census Handbook

Table 4. Animal population of different villages

16th Animal Census 1997

Villages- S.N.	Heads	Deowar	Nala	N Koti	Sum
1	Cows	138	154	166	458
2	Bulls	210	138	139	487
3	Buffaloes	207	74	44	325
4	Sheeps	230	64	220	514
5	Goats	60	44	127	231
6	Horses	4	6	10	20
7	Mules	12	8	15	35
8	Dogs	14	7	13	34
9	Hens	36	24	29	89
10	Plough	80	80	90	250

Source 16th Animal Census, 1987

Table 5.Home garden attributes for sampled household (HH) in the villages [Mean, SD, Proportion (%)]

SN.	Parameters	Deowar			Nala			NK Nv			NK vg		
		Mean	S.D.	%	Mean	S.D.	%	Mean	S.D.	%	Mean	S.D.	%
1	HG Availability (Nali/HH)	0.57	0.48	2.08	0.18	0.18	0.92	0.25	0.16	1.07	0.42	0.56	2.09
2	No. of Malta trees/HH	0.33	0.52	8.70	1.83	1.60	61.10	1.50	1.22	40.90	1.67	1.86	43.50
3	No.of all Fruit trees/HH	1.66	1.21	43.50	2.33	1.86	77.80	2.00	1.26	54.50	2.33	1.97	60.90
4	No. of Fodder & other trees/HH	2.17	0.75	56.50	0.66	0.82	22.20	1.67	1.37	45.50	1.50	1.38	39.10
5	Total No. of trees/HH	3.83	1.72	100.00	3.00	2.52	100.00	3.67	2.25	100.00	3.83	3.25	100.00
6	Density f trees/ ha	338.23			818.18			733.00			460.00		
7	Contribution of listed 8 sps.			86.95			100.00			100.00			91.30
8	MostFrequent sp.	Pulm, Banj, Timla		49.98	Malta		66.64	Malta		66.64	Malta		66.64
9	Most populated sp.	Banj, Timla		17.39	Malta		61.10	Malta		40.90	Malta		43.50
10	Second-most populated sp.	Akhrot, Pulm		13.04	Kharik		16.67	Timla		22.72	Kharik		17.39

Table 6.Agro-forestry Attributes sampled household (HH) in the villages [Mean, SD and Proportion (%)]

SN.	Parameters	Deowar			Nala			NK Nv			NK vg		
		Mean	S.D.	%	Mean	S.D.	%	Mean	S.D.	%	Mean	S.D.	%
1	Size of each field (Nali)	1.27	0.53	4.66	1.50	0.79	7.49	1.33	0.60	5.70	1.42	0.72	7.13
2	No. of fruit trees/ field	0.58	0.67	18.42	0.67	0.98	18.60	0.58	0.99	15.22	0.33	0.65	7.02
3	No.of fodder & other trees/field	2.58	1.24	81.58	2.92	1.31	81.39	3.25	1.80	84.78	4.42	2.50	92.98
4	Total No. of trees/ field	3.17	1.40	100.00	3.58	1.31	100.00	3.83	1.64	100.00	4.75	2.42	100.00
5	Density of trees/ ha.	124.92			119.44			143.75			155.88		
6	Contribution of listed 9 sps.			73.68			90.69			95.65			89.47
7	Most frequient sp.	Akhrot,Anyar,Chinchri		33.33	Chinchri,Thelku,timla		50.00	Chinchri		58.33	Thelku		66.66
8	Most populated sp.	Chinchri		15.78	Chinchri		18.60	Chinchri		19.56	Thelku		33.33
9	Second most populated sp.	Akhrot		13.15	Timla		16.28	Thelku		13.04	Kharik		17.54

SN.		Deowar		Nala		NK		Reserve forest	
		Mean	%	Mean	%	Mean	%	Mean	%
1	Density of trees/ ha.	720.00		620.00		750.00		540.00	
2	Most frequient sp.	Burans	26.40	Banj	21.00	Burans	29.80	Burans	25.90
3	Most populated sp.	Burans	26.40	Banj	21.00	Burans	29.80	Burans	25.90
4	Second most populated sp.	Banj	18.00	Burans	19.30	Lampatya	15.60	Banj	16.70
5	Sp./ ha	340.00		260.00		340.00		320.00	
6	Sp./ individual (1000)	493.00		417.50		454.00		609.00	

Table 8. Area under different crops / landuses [for kharif season]

S.No.	CropCode	Deo M(O)	S.D.	Nal M(O)	S.D.	Nk-n M(O)	S.D.	Nk-v M(O)	S.D.
A1	Ca	3.00	1.00						
A2	Cj-x	4.00	1.41						
A3	Ck	5.00	2.48			6.75	2.47		
A4	Cr	8.17	2.70	10.42	1.63	9.83	3.17	7.92	2.84
A4-I	Cr							1.95	1.46
A5	Cm			1.00		0.85	0.92	1.00	
A5-I	Cm							0.50	0.00
A6	Pt					2.17	1.04	2.50	
A7	Pc	2.00							
A8	Ps-x	1.75	0.35	1.50	0.71			2.50	0.71
A9	Vx	0.20		0.20				0.50	
A10	Sc					0.30			
A10-I	Sc							0.80	0.48
Tot		15.28	5.10	11.12	2.28	13.50	7.40	11.42	4.59
B1	Ca j-x	2.25	0.35	3.00		2.00		3.00	
B2	Cj-x k	2.83	1.76	2.50	0.71				
B3	Cj-x r	3.50	2.12						
B4	Ck Pt			3.00		2.67	1.26		
B5	Ck Ps-x	5.90	1.67	5.00	1.41	4.17	1.60	5.83	1.89
B6-I	Cr Pt							1.00	
B7	Cm Pc	1.17	0.58	0.25	0.07	0.30			
B8	Cm Vx	0.75	0.35	0.35	0.21	0.40		0.40	0.14
B9	Pc Vx	0.50	0.00			0.50		0.50	
B10	Vx Sc	0.35	0.21	0.20		0.40	0.14		
Tot		9.37	4.30	3.73	2.69	6.17	2.68	3.80	4.51
C1	Ca j-x k					2.00			
C2	Ca j-x Ps-x	1.75	0.35						
C3	Cj-x k Pt			2.00		2.75	1.06		
C4	Cj-x k Ps-x			5.00		3.75	1.77	5.00	
C5	Ck Pt s-x			6.00	2.00			7.50	0.71
C6	Pc Vx Sc	0.50		0.50		0.20	0.00	0.20	
		0.67	1.03	4.25	2.79	2.57	2.18	3.37	3.74
D1	Cj-x k Pt s-x			3.00				2.00	
		0.00	0.00	0.50	1.22	0.00	0.00	0.33	0.82
T cult.		25.32	7.42	19.60	3.25	22.23	5.75	18.92	6.27
C fallow		2.88	1.55	2.50		3.25	1.06	3.00	2.12
Tot land		27.23	7.28	20.02	3.80	23.32	6.68	19.92	5.64

Table 9.Area under different crops / landuses [for Rabi season]

S.No.	CropCode	Deo M(O)	S.D.	Nal M(O)	S.D.	Nk-n M(O)	S.D.	Nk-v M(O)	S.D.
A1	Cb			2.00	0.00	3.00			
A2	Cw	5.13	3.75	3.00		8.00		2.00	
A2-I	Cw	1.00	0.00					1.50	0.71
A3	Pm-I								
A4	Vo			0.30		0.25	0.07		
A4-I	Vo							1.50	
A5-I	Vc							1.00	0.61
A6	Vp	2.13	1.82	0.20	0.00	0.33	0.06	1.00	
A6-I	Vp							0.70	0.45
A7	Vy	0.50		0.20					
A8	Sg	0.20							
A9	Om	1.25	1.06	1.50					
		6.42	4.55	1.57	1.69	2.08	3.31	2.67	1.17
B1	Cb w	4.13	1.44	3.50	2.12	1.50		4.00	
B2	Cb Pm-I	4.50		3.00					
B3	Cb Om	2.25	0.35			3.00		2.00	
B4	Cw Pm-I					7.50	0.71	6.00	
B5	Cw Om	4.50	1.29	4.50	0.50	2.50		1.50	
B6	Pm-I Om			2.00		2.50		3.50	
B7	Vo Sg					0.50		0.20	
B7-I	Vo Sg							0.50	
B8	Vy Sg	0.35	0.21	0.30	0.17	0.25	0.07	0.50	0.00
		7.37	2.70	4.40	3.86	4.25	3.86	3.12	3.35
C1	Cb w Pm-I	5.00							
C2	Cb Pm-I Om					5.25	0.35		
C3	Cw Pm-I Om			6.50	2.72	9.17	2.75	5.90	2.46
C4	Vo y Sg	0.40	0.17	0.30		0.20	0.00	0.30	
		1.03	1.96	5.47	3.63	6.40	4.04	4.97	3.32
T cultivated		14.82	4.53	11.43	1.76	12.73	4.30	10.75	3.03
S fallow		12.17	3.67	8.58	2.94	10.58	2.87	8.17	3.04
C fallow		1.50						2.00	0.87
Total land		27.23	7.28	20.02	3.80	23.32	6.68	19.92	5.64

Table 10. Mean area, mean production and yield of major cereals

	Crops	Mean area	SD	Mean prod.	SD	Yield
Deowar	Rice	9.33	4.58	185.33	95.62	19.86
	Wheat	10.33	4.88	370.33	182.70	35.84
	Koda	9.67	4.79	411.67	183.69	42.59
Nala	Rice	10.17	1.97	315.83	76.05	31.07
	Wheat	9.33	2.14	284.00	57.58	30.43
	Koda	7.67	1.03	513.17	203.97	66.93
NKn	Rice	9.83	3.17	337.83	74.86	34.36
	Wheat	9.08	4.51	264.00	141.90	29.06
	Koda	10.25	2.98	514.00	136.73	50.15
NKv	Rice	9.38	2.66	292.50	59.60	31.17
	Wheat	7.67	4.03	190.67	100.98	24.87
	Koda	6.58	2.15	328.50	85.27	49.90

Table 11. Annual percental surplus/deficit estimation

	Crops	Prdn.	M A cons	surpl/def(-)	Ann. Percental
Deowar	Rice	185.33	488.00	-302.67	-62.02
	Wheat	370.33	281.00	89.33	31.79
	Koda	411.67	391.33	20.33	5.20
Nala	Rice	315.83	374.00	-58.17	-15.55
	Wheat	284.00	225.33	58.67	26.04
	Koda	513.17	239.33	273.83	114.42
NKn	Rice	337.83	305.33	32.50	10.64
	Wheat	264.00	180.67	83.33	46.13
	Koda	514.00	274.67	239.33	87.14
NKv	Rice	292.50	352.00	-59.50	-16.90
	Wheat	190.67	252.00	-61.33	-24.34
	Koda	328.50	204.00	124.50	61.03

Table 12. Abbreviations used in the text and tables

Parameters			
Community			
	Deo	Deowar	
	Nal	Nala	
	Nkn	Narayankoti vegetable cultivators	
	Nvg	Narayankoti conventional farmers	
	Veg. Cult	Vegetable cultivator	
	Conv. Far	Conventional farmer	
	HH	Household	
	LSU	Livestock standard unit	
Crop groups			
	C	Cereals	
	P	Pulse	
	V	Vegetable	
	S	Species	
	O	Oil seed	
	x	Miscellaneous crop of kharif seaosn	
	y	Miscellaneous crop of rabi seaosn	
Crops			
	Ca	Marcha	Amaranthus
	Cj	Jhangora	Barnyard millet
	Ck	Koda (Mandua)	Finger millet
	Cr	Shatti (Dhaan)	Paddy
	Cm	Mungri	Maize
	Pt	Tor	Pigeon pea
	Pc	Chimi	Bean
	Ps	Soyabean	Soyabean
	Sc	Mirch	Chilli
	Cb	Jaw	Barley
	Cw	Gehun	Wheat
	Pm	Masoor	Lentil
	Pl	Lobhia	Cow pea
	Vo	Pyaj	Onion
	Vc	Bandh gobhi	Cabbage
	Vp	Aalu	Potato
	Sg	Lahsun	Garlic
	Om	Gharrya,Torrya, Sarson	Mustard

Table 13. 'yield fluctuations:along and across parcel

A---dist	B-----prox	C----across
1.5178571	-2.5	1.744186
-0.666667	1.5267176	3.9370079
2	1.459854	-0.8
2.21	-2.666667	-5.063291
1.53	-1.183432	-3.2
2.6595745	-2.283105	4.8611111
1.46	-2.777778	-0.515464
0.00	-1.06383	3.0534351

Anova: Single Factor A--B--C

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	8	10.707281	1.3384102	1.2624047
Column 2	8	-9.48824	-1.18603	3.1472397
Column 3	8	4.0169851	0.5021231	12.323097

ANOVA

Source of V.	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Gr	26.458759	2	13.22938	2.371885	0.1178271	3.4667949
Within Grou	117.12919	21	5.5775806			
Total	143.58795	23				

Anova: Single Factor A---B

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	8	10.707281	1.3384102	1.2624047
Column 2	8	-9.48824	-1.18603	3.1472397

ANOVA

Source of V.	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Gr	25.491192	1	25.491192	11.561563	0.0043109	4.6001105
Within Grou	30.867511	14	2.2048222			
Total	56.358703	15				

Table 13. (Continued..)Yield fluctuations along and across parcel

Anova: Single Factor B----C

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	8	-9.48824	-1.18603	3.1472397
Column 2	8	4.0169851	0.5021231	12.323097

ANOVA

Source of V.	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Gr	11.399443	1	11.399443	1.4737162	0.2448425	4.6001105
Within Grou	108.29236	14	7.7351686			
Total	119.6918	15				

Anova: Single Factor *A—C*

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	8	10.707281	1.3384102	1.2624047
Column 2	8	4.0169851	0.5021231	12.323097

ANOVA

Source of V.	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Gr	2.7975039	1	2.7975039	0.4118367	0.5314063	4.6001105
Within Grou	95.098515	14	6.7927511			
Total	97.896019	15				

Table 14. ANOVA for comparing mean crop yields between the two farmer communities

[distant parcel:self harvest]

observations : yields of wheat (kg/nali)

veg cult	conv far
16.12	20.48
18.52	18.56
16.4	19.84
14.56	19.2
17.88	19.12
13.2	18.4
13.72	21.4

Anova: Two-Factor Without Replication D-S

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Row 1	2	36.6	18.3	9.5048
Row 2	2	37.08	18.54	0.0008
Row 3	2	36.24	18.12	5.9168
Row 4	2	33.76	16.88	10.7648
Row 5	2	37	18.5	0.7688
Row 6	2	31.6	15.8	13.52
Row 7	2	35.12	17.56	29.4912
Column 1	7	110.4	15.771429	4.1342476
Column 2	7	137	19.571429	1.1630476

ANOVA

Source of Va	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	12.356571	6	2.0594286	0.6360449	0.7017779	4.2838622
Columns	50.54	1	50.54	15.609043	0.0075305	5.9873742
Error	19.4272	6	3.2378667			
Total	82.323771	13				

Table 15. ANOVA for comparing mean crop yields between the two farmer communities

[distant parcel:reported]

observations : yields of wheat (kg/nali)

veg cult	conv far
13.39	19.89
19.44	15.27
17.66	21.74
16.67	21.28
15.96	16.06
16.00	15.00
14.40	16.03

Anova: Two-Factor Without Replication D-R

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Row 1	2	33.28236	16.64118	21.103202
Row 2	2	34.71162	17.35581	8.7247876
Row 3	2	39.398705	19.699352	8.3213884
Row 4	2	37.943262	18.971631	10.625723
Row 5	2	32.015841	16.00792	0.0050952
Row 6	2	31	15.5	0.5
Row 7	2	30.425641	15.212821	1.3213544
Column 1	7	113.52099	16.217284	4.0152245
Column 2	7	125.25644	17.893777	8.7241116

ANOVA

Source of V.	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	35.671665	6	5.9452775	0.8750701	0.562278	4.2838622
Columns	9.8371993	1	9.8371993	1.4479121	0.2741824	5.9873742
Error	40.764351	6	6.7940586			
Total	86.273216	13				

Table 16. ANOVA for comparing mean crop yields between the two farmer communities

[proxiamte parcel:self harvest]

observations : yields of wheat (kg/nali)

veg cult	conv far
23.88	22.44
22.92	25.44
24.32	20.28
24.08	26.24
27.16	25.68
24.48	23.68
23.72	25.44
21.56	23.76

Anova: Two-Factor Without Replication P-S

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Row 1	2	46.32	23.16	1.0368
Row 2	2	48.36	24.18	3.1752
Row 3	2	44.6	22.3	8.1608
Row 4	2	50.32	25.16	2.3328
Row 5	2	52.84	26.42	1.0952
Row 6	2	48.16	24.08	0.32
Row 7	2	49.16	24.58	1.4792
Row 8	2	45.32	22.66	2.42
Column 1	8	192.12	24.015	2.5051143
Column 2	8	192.96	24.12	4.0434286

ANOVA

Source of V.	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	25.8639	7	3.6948429	1.2947552	0.3709501	3.7870507
Columns	0.0441	1	0.0441	0.0154536	0.9045622	5.5914597
Error	19.9759	7	2.8537			
Total	45.8839	15				

Table 17. ANOVA for comparing mean crop yields between the two farmer communities

[proximate parcel:reported]

observations : yields of wheat (kg/nali)

veg cult	conv far
22.50	23.67
22.90	21.35
25.00	20.55
25.86	27.78
29.20	19.28
24.00	21.28
24,00	23.33
20.16	21.01

Anova: Two-Factor Without Replication P-R

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Row 1	2	46.16864	23.08432	0.682859
Row 2	2	44.25308	22.12654	1.198849
Row 3	2	45.54795	22.77397	9.910396
Row 4	2	53.63985	26.81992	1.83497
Row 5	2	48.47244	24.23622	49.22024
Row 6	2	45.2766	22.6383	3.708465
Row 7	2	47.33333	23.66667	0.222222
Row 8	2	41.16969	20.58485	0.3588
Column 1	8	193.6212	24.20265	7.048917
Column 2	8	178.2404	22.28005	6.967947

ANOVA

Source of Varia	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	45.76687	7	6.538125	0.874228	0.568098	3.787051
Columns	14.78563	1	14.78563	1.977021	0.202508	5.59146
Error	52.35118	7	7.47874			
Total	112.9037	15				

Table 18. Correlation between self harvested yield and reported yield

1-distant parcel

	veg cult		conv far	
	self harvast	reported	self harvast	reported
	16.12	13.39	20.48	19.89
	18.52	19.44	18.56	15.27
	16.40	17.66	19.84	21.74
	14.56	16.67	19.20	21.28
	17.88	15.96	19.12	16.06
	13.20	16.00	18.40	15.00
	13.72	14.40	21.40	16.03
coeff correl		0.4903347		0.2641524

2-proximate parcel

	veg cult		conv far	
	self harvast	reported	self harvast	reported
	23.88	22.50	22.44	23.67
	22.92	22.90	25.44	21.35
	24.32	25.00	20.28	20.55
	24.08	25.86	26.24	27.78
	27.16	29.20	25.68	19.28
	24.48	24.00	23.68	21.28
	23.72	24.00	25.44	23.33
	21.56	20.16	23.76	21.01
coeff correl		0.9383234		0.3324217

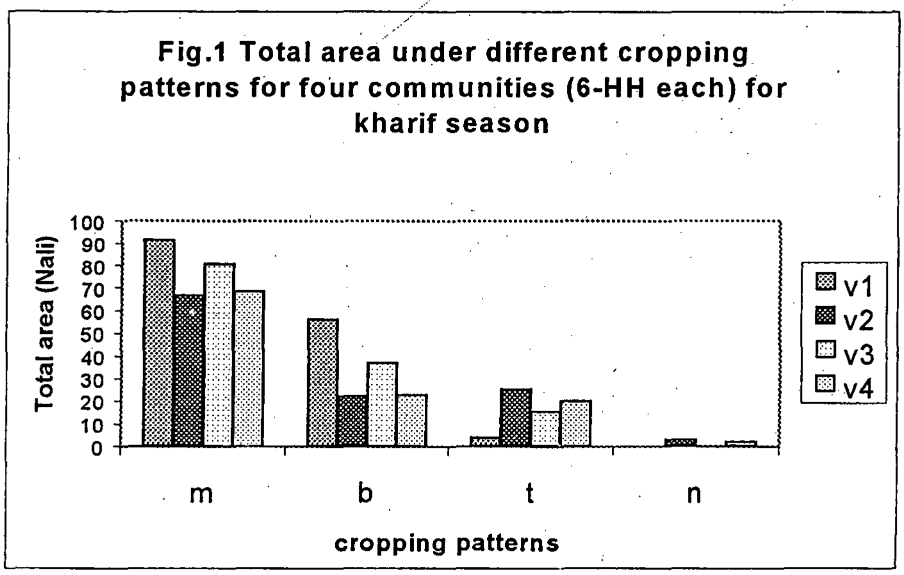


Fig.1 Total area under different cropping patterns for four communities (6-HH each) for kharif season
Total area (Nali)
100
90
80
70
60
50
40
30
20
10
0
m
b
t
n
cropping patterns
v1
v2
v3
v4

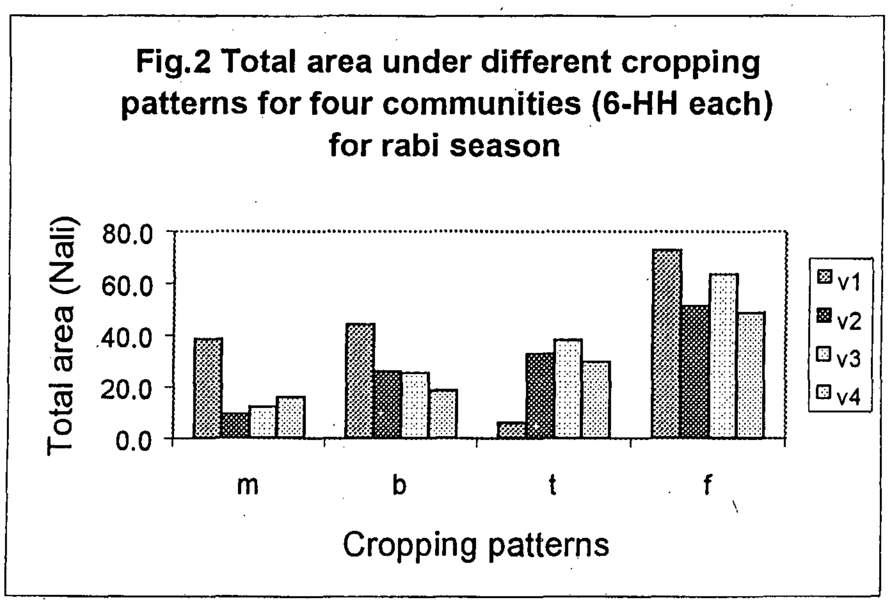


Fig.2 Total area under different cropping patterns for four communities (6-HH each) for rabi season
Total area (Nali)
80.0
60.0
40.0
20.0
0.0
m
b
t
f
Cropping patterns
v1
v2
v3
v4

Fig.3 Area/ HH and mean yield

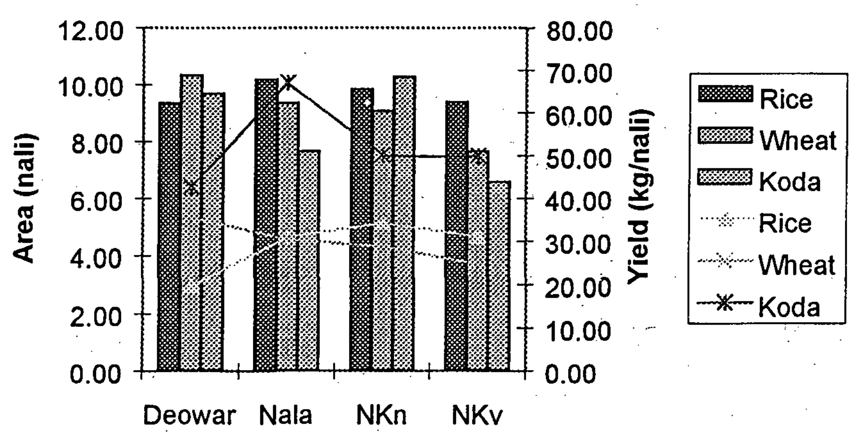


Fig.4 Mean annul consumption of staple crops for different communities

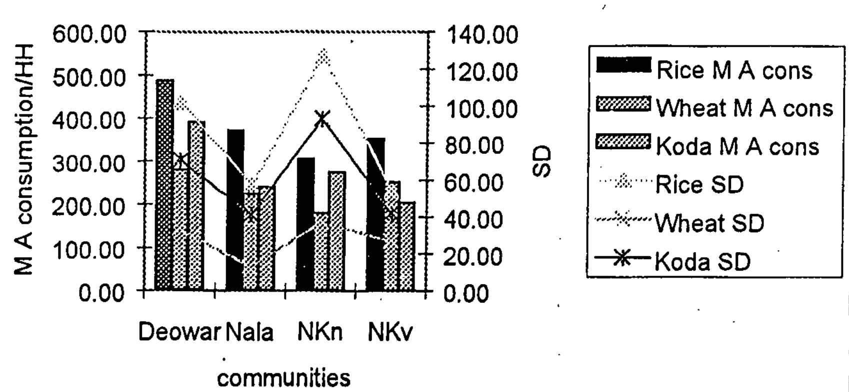
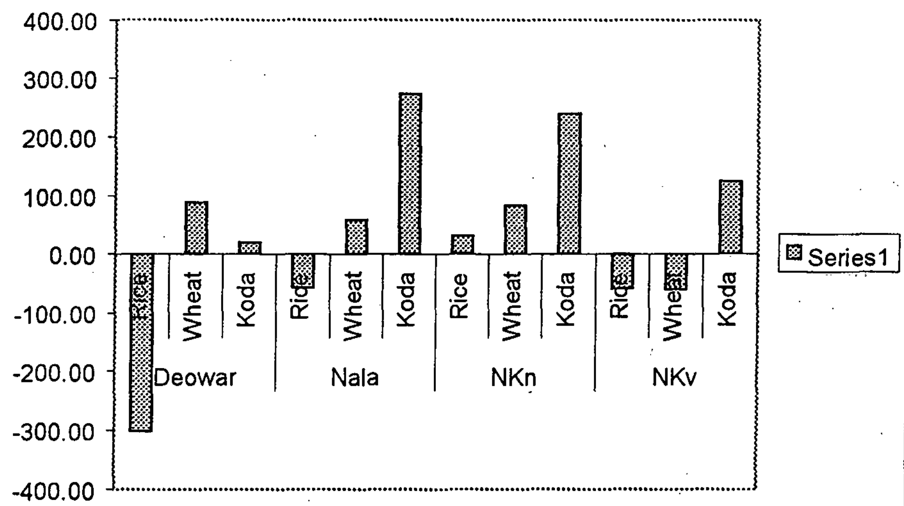


Fig.5 Percental surplus/deficit (of ann. cons.)



REFERENCES

Altieri, M. A. and Leibman, M., 1988: *Weed Management Agroecosystems: Ecological Approaches*. CRC Press, Boca Raton, Florida.

Anonnymous. 1979: *District Gazetteers, Chamoli-Garhwal*. Government Press, Lucknow, India. pp. 1-182.

Anonymous. 1961, 1971 1981 1991: *Census for India. Primary Census Abstract, District Chamoli.* Governmentt of India.

Bentley, J. W., 1987: Economic and ecological approaches to land fragmentation: in defence of a much maligned phenomenon. *Annual Review of Anthropology*, 16: 31-67.

Binns, B. O., 1950: The consolidation of fragmented agricultural holdings. FAO *Agricultural Studies,* 11. Food and Agriculture Organisation of the United Nations, Washington D.C.

Bonner, J. P., 1983: Fragmentation and consolidation in north Indian agricultural holdings. *The Eastern Anthropologist,* 36: 321-334.

Browman, D.L., 1987: Agro-pastoral risk management in the Central Andes. *Research in Economic Anthropology*, 8: 171-200.

Brush, S. B., 1977a: *Mountain, Field, and Family*. University of Pennsylvania Press, Philadelphia. 199 pp.

Brush, S. B., 1977b: The myth of the idle peasant: employment in a subsistence economy. *In* Halperin, R. and Dow, J. (eds.), *Peasant Livelihood: Studies In Economic Anthropology And Cultural Ecology*. St. Martin's Press, NY, pp. 60-78.

Brush, S. B., 1986: Genetic diversity and conservation in traditional farming systems. *Journal of Ethnobiology*, 6: 151-167.

Caraco, T., 1981: Energy budgets, risk and foraging preferences in Dark -Eyed Juncos (*Junco hyemalis*). *Behavioral Ecology and sociobiology,* 8: 213-217.

Caraco, T., Martindale, S. and Whitham, T. S., 1980: An empirical demonstration of risk - sensitive foraging preferences. *Animal Behaviour,* 28: 820-830.

De Vries, J., 1974: *The Dutch Rural Economy in the Golden Age,* 1500-1700. Yale University Press, New Haven CT. 316 pp.

Figueroa, A. 1984: *Capitalist Development and the Peasant Economy in Peru.* Cambridge University Press, Cambridge.140pp.

Friedl, J., 1974: *Kippel: A Changing Village in Alps.* Holt, Rinehart and Winston, NY. pp. 129.

Gliessman, S. R., 1989: *Agroecology Researching the Ecological Basis for Sustainable Agriculture.* Springer Verlag New York.

Goland, C., 1993: Field scattering as Agricultural Risk Management-A case study from Cuyo Cuyo, Department of Puno, Peru. *Mountain Research and Development,* 13: 317-338.

Guillet, D., 1981a: Agrarian Ecology and peasant production in the Central Andes. *Mountain Research and Development,* 1: 19-28.

Guillet, D., 1983: Toward a cultural ecology of mountains: the Central Andes and the Himalayas compared. *Current Anthropology,* 24: 561-567.

Harden, C. P., 1996: Interrelationship between land abandonment and land degradation: A case study from the Equadorian Andes. *Mountain Research and Development* 16 (3): 274-280.

Jodha, N. S., Banskota, M. and Partap, T.,1992: Strategies for The Sustainable Development of Mountain Agriculture: An Overview. *In* N.S. Jodha et al. (ed). *Sustainable Mountain Agriculture.Perspectives and Issues Vol.1.* Oxford & IBH Publishing CO. Pvt. Ltd.

King, R. and Burton, S., 1982: Land fragmentation: notes on a fundamental rural spatial problem. *Progress in Human Geography,* 6: 475-494.

Kristensen, S. P., Thenail, C. and Kristensen, L., 2001: Farmers involvement in landscape activities: An analysis of the relationship between farm location, farm characteristics and landscape changes in two study areas in Jutland, Denmark. *Journal Of Environmental Management,* 61: 301-318.

Mahajan, N., Kalia, M. and Kataria, S. R., 1997: Food consumption by rural population of selected areas of Mandi District of Himachal Pradesh, India. Journal of Rural Development. 16: 167-171.

Maikhuri, R. K. 1991: Fuel wood consumption pattern of different tribal communities living in Arunachal Pradesh in North- East India. *Bioresource Technology,* 35: 291-296.

McCloskey, D. N., 1975: The persistence of English common fields. In Parker, W. N. and Jones,E.L.(eds). *European Peasants and Their Markets.* Princeton University Press, Princeton, N J, pp. 79-119

McCloskey, D. N., 1976: *English open fields as behaviour towards risk.* In Uselding, P. (ed), Research In Economic History, Vol. 1. JAI Greenwich, CT, pp. 124-170.

McRae, S. D., 1979: *Resource Allocation Alternatives in an Andean Herding System: A Simulation Approach.* Cornell University Latin American Studies Programme Dissertation Series No. 82. Ithaca, NY. 318pp.

Mishra, B. K. and Ramakrishnan, P. S., 1981: The economic yield and energy efficiency of hill agroecosystems at higher elevations of Meghalaya in north -eastern India. *Acta Ecologica Applicata,* 2: 369-389.

Mitchell, R., 1979: *An Analysis of Indian Agroecosystems. Interprint,* New Delhi,India. 180 pp.

Negi, G. C. S. and Singh, S. P., 1990: Energy linkage in Central Himalayan agroforestry system. *In Agroforestry: Its Present Status and Scope for Future Development* in Farming Systems. (ed), R. K. Singh, I. P. Singh and A. K. Samena. Narendradeo University of Agriculture and Technolgy, Faizabad, India. pp. 171-181.

Negi, G. C. S., Singh, V. and Singh, S. P., 1989: Energetics of agricultural system. An experimental study from the Central Himalaya. In *Dimensions of Development Planing. Vol. 2* (ed) D. C. Pandey and P. C. Tiwari, New Delhi, India. pp. 459-476.

Netting, R. McC., 1981: *Balancing on an Alps, Ecological Change and Continuity in a Swiss Mountain Community.* Cambridge University Press, Cambridge. 278pp

Orlove, B. S. and Guillet, D. W., 1985: Theoretical and methodological consideration on the study of mountain peoples: Reflections on the idea of subsistence type and the role of history in human ecology. *Mountain Research and Development,* 5: 3-18.

Pandey, V. and Singh, J. S. 1984: Enegy flow relationships between agro- and forest-ecosystems in Central Himalaya.*Environmental Conservation,* 11: 45-53.

Poudel, D. D., Midmore, D. J. and Hargrove, W. L., 1998: Analysis of commercial vegetable farms in relation to sustainability in the uplands of Southeast Asia. *Agriculture Systems 58(1): 107-128*

Poudel, D. D., Nissen, T. M. and Midmore, D. J., 1999: Susstainability of commercial vegetable production under fallow systems in the uplands of mindanao, the Phillipines. *Mountain Research and Development*, 19 (1): 41-50.

Rai, S. C., 1993: Energetics of cropping system: A case study from Central Himalaya. *International Journal of Ecology and Environmental Science*, 19: 25-33.

Ralhan, P. K., Negi, G. C. S. and Singh, S. P., 1992: Structure and function of the agroforestry system in the Pithoragarh district, Central Himalaya: An ecological view point. *Agriculture Ecosystem and Environment*, 35: 283-296.

Ramakrishnan, P. S., Rao, K. S., Kothyari, B. P., Maikhuri, R. K. and Saxena, K. G., 1992: Deforestration in Himalaya: Causes Consequences and Restoration. In *Resoration in Degredation Land: Concept and Strategies* (ed). J. S. Singh. Rastogi Publication, Meerut, India. pp. 271-289

Ramakrisnan, P. S., 1992: *Shifting Agriculture and Sustainable Development- An Interdisciplinary Study from North-Eastern India.* Man and the Biosphere Series. Vol. 10 UNESCO, Paris.

Reiger,H.C.1981:"Man versus Mountain:The Destruction of the Himalayan Ecosystem."In J.S. Lall and A.D.Moodie(eds).*The Himalaya:Aspects of Change*.Delhi:Oxford University Press.

Roumasset, J. A., 1976: *Rice And Risk: Decision-Making Among Low-Income Farmers.* North Holland Publishing Co. Amsterdam. 251 pp.

Sarmiento, G., 1986: Ecological features of climate in high tropical mountains. In Vuilleumier, F. and Monasterio, M., (ed) *High Altitude Tropical Biogeography.* Oxford University Press, NY, pp. 11-45.

Semwal, R. L., Maikhuri, R. K.,1996: Structure and functioning of traditional hill agroecosystems of Garhwal Himalaya. *Biological Agriculture and Horticulture*, 13: 267-289.

Sen, K. C., Ray, S. N. and Ranjhan, S. K., 1978: *Nutritive values of Indian cattle feed and feeding animals.* ICAR, New Delhi, pp. 12-19.

Sharma, S. and Jodha, N. S. 1992: Mountain Farmers Response to Development Efforts: Comparative Perspectives from the Countries of the Hindu Kush-Hiimalayan Region. In N. S. Jodha et al. (ed) *Sustainable Mountain Agriculture.Perspectives and Issues Vol 1.* Oxford & IBH Publishing CO. Pvt. Ltd.

Shirar A. J., 2000. Agricultural intensity and its measurement in frontier regions. *Agroforestry Systems,* 49: 301-318

Singh, J. S. and Singh, S. P. 1987: Forest Vegetation of The Himalaya. *Bot.Rev,* 53(1): 80-192.

Singh, J. S. Pandey, U. and Tiwari, A. K., 1984: Man and forest. A central Himalayan case study. *Ambio,* XIII: 74-80.

Singh, S. P., Negi, C. G.S., Pant, M. C. and Singh, J. S., 1992: Economic consideration in the Central Himalayan agroecosystem. In *The Price of Forests.* A. Agarwal, (ed.), pp. 291-296. Centre for Science and Environment; New Delhi India.

Stephens, D. W. and Charnov, E. L. 1982: Optimal foraging: Some simple stochastic models. *Behavioral Ecology and Sociobiology,* 10: 251-263.

Swarup, R., 1993: *Agriculture Economy of Himalayan Region: With Special Reference to Garhwal Himalaya, Vol. 2.* Gynodaya Prakashan, Nainital, India.

Weinberg, D., 1972: Cutting the pie in the Swiss Alps. *Anthropological Quarterly,* 45: 125-131.

Weinstein, D. A., Shugart, H. H. and Brandt, C. C.1983: Energy flow and the persistence of a human population: a simulation analysis. *Human Ecology,* 11: 201-225.

Yadav, Y. 1992: Farming-Forestry-Livestock-Linkages: A Component Mountain Farmers' Strategies (Nepal). In N. S. Jodha et al. (ed) *Sustainable Mountain Agriculture. Perspectives and Issues Vol 1.* Oxford & IBH Publishing CO.Pvt. Ltd