SPATIO-TEMPORAL DYNAMICS OF DIVERSITY OF TRADITIONAL GRAIN LEGUMES OF CENTRAL HIMALAYA

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Abstract:

Legume fixes atmospheric nitrogen and hence plays a fundamental role in every agrarian ecosystem. In Central Himalayan region where local economy is agriculture based and more than 85 % agricultural land is rainfed and practiced on slopes of hilly terrains, importance of legume crops as a "Soil Fertility Maintainer" cannot be ignored. But changes in food habit, socio-economic and cultural transformation has led to reduction in area under cultivation, crop intensity and erosion in legume crop diversity. A recent in-depth survey and field experiment conducted in different villages of the Mandakini valley of Central Himalaya reveals 35 % decline in area under traditional legume crop cultivation over a period of more than two decades (from 1980-2005). Among all the studied crops, the area under cultivation of Glycine max (Black soyabean) has reduced to a large extent due to its replacement by another Glycine max variety viz White soyabean. Substantial decline in legume grain yield (kg/ha/yr) has also been noticed and prominent crops like Glycine max (Black soyabean), Macrotyloma uniflorum, Vigna mungo, Vigna unguiculata, Cajanus cajan and Vigna angularis have shown 58%, 36%, 28%, 27%, 25% and 16% reduction respectively in yield. The per capita per year production has declined by 28 % and consumption has turned down from 70 gm/capita/day to 56 gm/capita/day. All this lead to an out source dependency for pulses and about 2-3 kg pulses is purchased per capita per year.

The Central Himalayan farming communities are the one, which remained predominantly rural despite of decades of modernization. Even today, every aspect of economy, and day-to-day livelihood of the majority of its population are governed by agriculture sector. The stability and sustainability of its agriculture is therefore of much of significance. The decline in interest and reduction in area under cultivation of some of the prominently cultivated legume crops in Himalayan agro-ecosystem are a major issue of concern at local, regional, national and global level. This decline of legume crops is likely to continue unless efforts are made to improve yield potential with low level of inputs on one hand and on the other legume crop cultivation need to be linked with market economy, while adding value locally. Therefore, present paper deals with the status, changing scenario, yield assessment, factors involved in loss of legume crop diversity and recommend strategies for their conservation and management.

Keywords: Central Himalaya, traditional legume crops, genetic erosion, ethno-medicinal uses, organic farming, conservation.

Introduction

Like many mountain countries, the Indian Himalayan region is characterized by a complex mosaic of distinct agro-ecosystems, differentiated by their climatic, edaphic, and geological characters, vegetation and cropping patterns, crop rotations and other features.

Owing to diverse topography and climatic conditions, Himalaya represents different agro-ecological zones and each of these zones in turn comprised of myriad microhabitats. It is within this diversity of habitats that an amazing variety of legumes and other crops have been developed over the millennia by the hill farmers and thus this region is considered as an abode of rich agricultural crop diversity specifically the legume crops. There are many species and varieties of legumes that are cultivated by the farming communities like Macrotyloma uniflorum, Vigna radiata, V. mungo, V.angularis, V.unguiculata, Pisum arvense, P. sativum, Glycine max , Lens esculenta, Vicia faba. Besides, several species and varieties of Phaseolus are exclusive to higher Himalaya. This diversity is neither accidental nor it is purely natural. It is the outcome of thousand of years of crop selection and management practices experimented and implemented by the hill farmers.

Legume crops are of multipurpose of paramount importance and play significant role in providing agricultural, food, nutritional and livelihood security to the hill farmers. They have been closely interlinked with cereals in a way that in agriculture legumes complement cereals in terms of cropping pattern and crop cycle and provide rich protein and a variety of minerals and nutrients to a cereal based diet (FAO, 1982). Often described as “poor men’s meat” (FAO, 1982), pulses constitute the major protein source in the diets of local hill communities in Himalaya. Some of the species are of immense significance as providers of fuel, fodder and medicines to the farming communities and other species have an important position in traditional rituals and ceremonies.

Legume fix atmospheric nitrogen and have enormous potential to fulfill the nitrogen requirements of soil, associated and subsequent crops and hence are an eco friendly option against inorganic fertilizer and organic manure. The later though has been traditionally used in hill agro-ecosystem, are less available due to dwindling forest cover and decrease in domesticated animal population (Semwal and Maikhuri, 1996). Many of these Himalayan traditional legume crops have high ecological and economic potential and thrive well in adverse environmental conditions with low external inputs (Maikhuri et al., 1996).

However, during recent past, a decline in interest of local farming communities towards traditional legume crop cultivation has been observed as a result of climatic, cultural and socio-economic changes. This decline is perceived as a big threat to the traditional legume crops and their wild relatives and consequently the subsistence farming system of the region appears to be in jeopardy. Present paper is an attempt (i) to understand the traditional Himalayan agro-ecosystem in general and legume crop cultivation in particular (ii) to understand the current status and changing scenario of prominent legume crops at two points of time (1980-2005) in terms of area under cultivation and grain yield, (iii) to document ethno-medicinal uses, socio-economic, cultural significance and religious believes of farming communities in relation to legume crops, (iv) to assess the factors and processes involved in loss of legume crop diversity and (v) discuss policy and suggest appropriate strategies for their conservation and management.

Study area and methodology

Present study was carried out in the Central Himalaya (Uttarakhand) situated between 20^{0}31’9” to 31^{0} 26’5” N & 77^{0}35’5” to 80^{0}6’ E (Maikhuri et al., 2001) with particular emphasis on Mandakini valley where a total of 10 villages, all falling in Rudraprayag district (Fig.1) were selected. A brief description and profile of these villages is given in Table1.

An extensive cross sectional survey of all the selected villages was carried out to collect the baseline information which included per household land holding size and based on this, households of each village were grouped into three categories viz household below 0.2-hectare, between 0.2 to 1 hectare and above 1-hectare landholding. About 60 % households were interviewed in each category.

A door-to-door survey was conducted in selected households of each village to enumerate total landholding, area under cultivation of each crop, crop composition, cropping pattern, crop rotation and commonly cultivated crops. The information was collected through informal discussion with knowledgeable members of the families, particularly with women folk, as they are actively involved in all agricultural activities. Each family was visited 3-4 times during the cropping season so as to collect authentic information.

Information about area under each crop in the past (1980) and at present (2005), changes in landrace diversity of legume crops and changes in production, consumption and marketing status was assessed by interviewing the head of each selected household. Respondents, particularly the elder persons, were asked to prioritize the probable reasons for change in legume crop diversity and cropping pattern in their own farm fields in particular and in the village in general.

To document ethno-medicinal, socio-cultural and religious knowledge pertaining to legume crops, farmers of different age groups (18-30, 31-60 and above 60) were interviewed. The first section of questionnaire focused on information concerning medicinal properties, specific characteristics and mode of use of each legume crop. Farmer’s perception on issues like climate change, organic farming, major problems related to farming, sustainable agriculture and challenges for sustainable management of traditional agriculture were part of the other section of questionnaire.

Verification of grain yields reported by the respondents was done using actual grain harvest values from random plots (5 replicates) for each of mix and mono cropping. In these plots economic yield was assessed by laying 15 quadrates of 2 X 2 m size.

Results and Discussion

Legume cropping in Central Himalaya

The Central Himalayan farming communities practice low input agriculture with a major concern for conserving crop diversity at both species and intraspecies level (Bisht et al., 2006). The cropping pattern in this region is built around two main crop seasons viz Rabi – the winter crop season (from October to March) and Kharif – the summer crop season (from April to October). The predominant form of cultivated land is rainfed (85%) and irrigated area contributes merely about 15 % (Maikhuri et al., 1996). The agricultural operations and crop composition under both the system are exclusive. In irrigated land wheat and paddy are the major crops whereas in rainfed agriculture different traditional crops like Eleusine coracana, Amaranthus viridis, Hordeum vulgare, Panicum miliaceum, Perilla frutescense, Secale cereale, Setaria italica and various legume crops like Macrotyloma uniflorum, Vigna radiata, V. angularis, V. unguiculata, Pisum arvense, Glycine max are cultivated and hence play a vital role in conserving hill crop diversity.

The cropped area under rainfed agriculture is generally divided into two almost equal halves locally called as 'Mullasari' and 'Mallasari'. Three crops in two years are harvested in these areas and the crop sequences are maintained in a manner to have one half of the rainfed area (Mullasari or Mallasari) under fallow phase during Rabi season and either main cereal crop (paddy) or millet-legume mixture during Kharif season (Figure 2). In irrigated agriculture 2 or 3 crops are cultivated per year.

Grain legumes are primarily rainfed, kharif season crops. However a few like pea and lentil are cultivated during Rabi season. Some of them are cultivated on the bunds (field margins) of paddy field in irrigated land whereas few are confined to small areas of kitchen gardens. In Himalayan region legumes are customarily mixed cropped with traditional non-legumes like Eleusine, Echinochloa, Maize and Amaranthus and this practice is locally known as "Barahnaja". Literally the term indicates that about 10-12 crops are grown together in combination so as to obtain maximum and diverse yield on per unit area basis (Shiva and Vanaja, 1993; Ghosh and Dhyani, 2005). Growing non-leguminous crops with legumes provide climbing support to the later, reduces disease attack, facilitates weed management and reduces the harmful impacts of continuous and intensive cereal cultivation on soil fertility.

Legume crop cultivation practices are simple and do not require much labour and attention like other crops. When wheat is harvested, the field is ploughed only once and seeds are sown while ploughing. Being a rainy season crop, it does not require irrigation and rainwater fulfills the water requirement of the crop. After 20-25 days of germination, when the crop roots grasp the soil firmly a local agriculture instrument called "Maaua" is applied to the field to facilitate soil loosening. This is followed by first weeding. Second weeding is performed 20-25 days after first weeding. With in five months the crop starts maturing. Crop maturity time varies from crop-to-crop and generally large seeded crops like Phaseolus and Glycine mature early. For use as vegetable, green and succulent pods of some legumes like Phaseolus and Vigna are harvested early, but grains gets ready for harvesting around 135 to 150 days.

Crop diversity and genetic erosion

Over centuries, the Himalayan traditional societies and farmers have continuously adopted and modified the rich genetic material available to them from nature. They further developed knowledge, skills and techniques (KST) to enrich their natural/traditional crop treasure. The diversity of crops/legume crops is the consequence of thousands of years of deliberate selection, planned exposure to a range of natural conditions, adaptation to localized environments, field level cross breeding, and other management systems which farmers have tried out. Within a village landscape of central Himalaya, domesticated legume crop diversity can be spread over time and space over vertical and horizontal layers within the agricultural field and within or between species of plants. Apart from ecosystem characteristics, economic, cultural, religious and survival factors have played a key role in this diversification (Maikhuri et al., 1996, 1997, 2001).

At a time when the world is looking for sustainable use of biodiversity, Himalayan agro-ecosystem has great relevance. A variety of changes in traditional Himalayan agro-ecosystem have emerged in the recent past in response to population pressure, ineffective technological innovation, market forces, economic growth, inappropriate social welfare and environment conservation policies (Maikhuri et al., 2001). Negative trends in agro-ecosystem such as decline in crop yield, expansion of agriculture on marginal land (Eckholm, 1975; Rao, 1997; Singh et al., 1984), declining carrying capacity of the rangeland (Rao, 1997; Nautiyal et al., 2003; 2005; Chandrasekhar et al., 2007), weed infestation (Saxena and Ramakrishanan, 1984), loss of domesticated genetic diversity (Maikhuri, 1993), soil erosion (Sen et al., 1997; 2002), social disintegration (Ramakrishnan, 1992) dominates the debate on sustainable agriculture in Himalaya. A shift from traditional to modern, intensive agriculture system has been observed in Himalayan region as a result of increasing market forces (Maikhuri et al., 1996; Palini et al., 1998; Paroda, 1997). This result in major loss in crop diversity and legumes being an important component of traditional hill cropping systems are also affected. In spite of being an important component of hill agricultural system and economy, legume production showed a stagnancy or decline since past few decades (Maikhuri et al., 1997). Dispite of being first, both in area under cultivation and gross production of pulses, India stand at 118th position on account of productivity (Sirori, 2006). Substantial erosion in area under legume crop cultivation has been observed with in a period of more than two decades (Table 2). On an average basis it was estimated that about 12 hectare land per village was under legume crop cultivation in the study area during 1980, however it has reduced to 9.6 hectare per village in 2005 with about 20% reduction. Though the decline seems low but it is due to the introduction of Glycine max (White soyabean). If as an introduced crop the area under cultivation of Glycine *max* (White soyabean) is excluded, about 35% decline in area under traditional legume crops cultivation has been noticed. Among the studied legume crops, the area under cultivation of Glycine max (Black soyabean) has declined considerably, i.e. from 1.6 to 0.4ha /village (75 % reduction) owing to its replacement by Glycine max (White soyabean). Similarly other crops like Lens esculenta, Pisum sativum, Macrotyloma uniflorum, Vigna angularis and Cajanus cajan have 70%, 60%, 44%, 16%, and 13% reduction in area under cultivation, respectively. Similar trends have been reported by Maikhuri et al. (2001) from central Himalaya when they observed about 72-95 % decline in area under Macrotyloma uniflorum, Vigna species. Some important causes for decline in area under legume crops are decline in mono cropping practice, reductions in legume crop proportion/density under mixed cropping and shift towards cash and market oriented introduced/traditional crops.

Figure 3a, 3b, 3c and 3d represents the crop distribution pattern and proportion (in percentage) of land, out of every one hectare, under each legume and associated non-legume cultivation at two points of time during kharif and rabi season. Though, compared to 1980, a decline in area under each crop has been noticed in 2005 in both the seasons, but the most surprising result is that during 1980s all the agricultural land was under crop cultivation but during 2005, out of every 1 hectare about 14% land is either left abandoned or under grass cultivation in each cropping season. Also during 1980s only 1% land was under Glycine max (White soyabean) cultivation but in 2005, 11% land is under White soyabean cultivation. The result explains mode of shifting agriculture and pattern of land transformation from agriculture to barren/grassland with in the study area due to lack of man-power or other constraints. Similar situation prevails in the other villages also.

Yield, consumption pattern and marketing

Substantial decline in legume and associated crops per unit area grain yield (kg/ha/yr) under various cropping patterns has been noticed over a period of more than two decades (Table 3). About two decades back monocropping of legumes was common but now only few areas or regions of higher altitude in the study area still practice monocropping. Among various monocropped legumes, monocropping of Glycine max (Black soyabean) has completely been replaced by Glycine max (White soyabean). Though, the later is not new to the region, but owing to high market demand it is now monocropped extensively. Under mixed cropping rabi season crops viz Lens esculenta and Pisum sativum have shown 70 and 60 % reduction in per unit area grain yield whereas kharif season legume crops such as Glycine max (Black soyabean), Macrotyloma uniflorum, Vigna mungo, Vigna unguiculata, Cajanus cajan and Vigna angularis have shown 58%, 36%, 28%, 27%, 25% and 16% reduction in grain yield, respectively. Summing up, about 8% decline in per unit area legume grain yield under mono cropping and about 23 % and 64 % decline in kharif and rabi season legume grain yield under mixed cropping has been observed. If as an introduced crop production of White soyabean is excluded about 34% decline in per unit area grain yield under mono cropping and about 30 % decline in kharif season legume under mixed cropping has been observed.

Considerable changes have been observed in per capita production, consumption and marketing status of legume crops with in the studied villages (Figure 4). During 1980s legume crop production was sufficient to meet per capita needs. On an average about 44 kg pulse was produced per capita/yr in 1980 which included all the prominent pulses specific to that area but now it has reduced to 32 kg/capita/yr with about 28% decline. Consequently the per capita consumption has declined sharply from 70 gm/capita/day to 56 gm/capita/day as against the WHO recommendation of 80 gm/capita/day (Sirori, 2006). Earlier, there was no dependency on market for pulses however, now about 2-3 kg pulse per capita per year is purchased from market. Selling of pulses in the local market has declined considerably i.e. about 39 %. The decline is not in terms of quantity only but in terms of diversity also. Vigna angularis, Glycine max (Black soyabean) and Cajanus cajan were the prominent crops that were exchanged or often marketed in the past. However, now only Glycine max (soyabean) and a small proportion of Cajanus cajan (about 3 kg/capita/yr) are exported to market. Though Vigna angularis has higher per capita production compared to Cajanus cajan but due to high market prize Cajanus cajan is preferred for selling.

The critical reason for decline in per capita production of pulses is due to decrease in area under cultivation of pulses and per unit area grain yield. Though increase in population in last 20 years could be a reason for this decline but here in past 10 years due to high migration rate, the net population dependent on agriculture has either remained constant or declined in many cases (Table 4). Also availability of government and private jobs with in or surrounding the villages, further reduces the per capita dependency on agriculture. So it can be concluded that the decline in per capita production and thus consumption and selling is due to decline in area under cultivation and per unit area grain yield as illustrated in Table 2, 3 and Figure 3a, 3b 3c, 3d.

Ethno biological aspects

Though, legumes build soil fertility and thus considered as an integral part of any cropping system, but in central Himalayan region, these are also important as an essential component of socio-economic, cultural and traditional life of the local communities. Several varieties of legumes are grown in many parts of the Himalayan region for their uses during festivals, marriages or other auspicious occasions, several others are grown for their nutritional values, taste, colour or smell, yet other for their medicinal and soil fertility enhancement characteristics (Table 5).

Most of these Himalayan legumes are used to prepare traditional dishes viz fana, bhatwani, chainsa etc. But due to changing life styles the traditional cuisines/dishes are loosing their identity. Important lessons on linking traditional food crops and dietary diversity to rural, urban and semi-urban health care are emerging from research and promotional activities (Maikhuri et al., 2001). Efforts are also made to make these foods available at various fetes and festivals to make these healthy and traditional cuisines familiar to people of other region. Such an effort will popularize local recipes and increase their market demand. Market acts as powerful factor for determining the transformation of food systems. Consumers demand for traditional foods will help in conserving traditional knowledge systems associated with preparation of such food on one hand and traditional agro-legume diversity on the other hand.

Factor and processes responsible for decline of legume crop diversity

As revealed by the farmers', the net decline in legume crop diversity is a collective consequence of various factors and issues like environmental perturbations, changed food habits, socioeconomic factors, ignorance towards rainfed agriculture, unavailability of seeds, disease and pests attack etc.

About 90% respondents reveal that weather uncertainties and changes in food habits are the two major reasons for decline in legume crop cultivation. Being a rainfed, rainy season crop, the dependency of pulses on weather condition is very high and due to their low yield performance, their production is affected much adversely compared to cereals under unfavorable climatic conditions. Thus farmers give more emphasis to paddy cultivation in irrigated/rainfed land since paddy depend less on rain and also even in unfavorable condition farmers are not completely detriment because their yield is about 3 to 4 times higher than legumes. Also legumes are much susceptible to abiotic constraints like water logging and frost compared to paddy. Secondly, changed food habits where consumption of traditional crops is considered as a sign of backwardness lead to a decline in interest towards legume and traditional crop cultivation. Similar results were obtained by Maikhuri et al. (2001), when they observed replacement of Macrotyloma uniflorum by kidney bean, wheat and potato owing to changed food habits and increased market demand for potato and kidney bean. While providing energy, the later do not provide enough proteins and micronutrients, leading to deficiency disease and lowering of health status of the concern population (shiva and Vanaja, 1993). Loss by pests and wild animals is high in pulses as compared to other crops and about 30 % respondent considered it as a measure problem for growth in pulse production. Among some general reasons, low profitability, traditional farmer's caution and conventional Indian food habit where pulses are considered as associates of main food wheat and rice lead to reduced pulse production. At management level unavailability of improved technology, lack of hill suitable high yielding cultivars and unavailability of market are the major constrains to legume production in Himalayan region.

Priority intervention for conservation and management

Though, not exactly considering the declining status and conservation/ management view in mind, but various plans and strategies to enhance the production, per unit area productivity, distribution facility and availability of market for legume crops, has been proposed in Uttarakhand state agriculture policy 2001. The important focus of the policy is on (i) to increase research work on legume crops like Vigna mungo, Vigna radiata, Glycine max (Black soyabean), Glycine max (White soyabean) and Macrotyloma uniflorum and (ii) to develop proper techniques to increase productivity and decrease the cost of production of White soyabean. Also to maintain continuity in production, proper storage and distribution facility for White soyabean has to be raised and made available. Though, the proposed steps to improve legume crop cultivation and production in the policy are effective ones but the only short coming is that as compared to other traditional legumes, White soyabean has been given much emphasis. The government must take steps towards enhancing the production of other traditional legume crops also and should make available proper storage, distribution and market facility for other legumes also as it is available for white soyabean. In addition to this few other steps that can enhance legume crop cultivation are: At village level attempts, the farmers/villages that have continued and maintained, traditional farming systems in remote/ isolated and marginal areas need to be benefited with viable incentives, which could be either monetary or non monetary (Nautiyal et al., 2005) which may help in conservation of traditional legume crop diversity. Besides there is a strong need to reorient agricultural research and development and related practices in tune with the changing scenario of socioeconomic conditions, agro ecological situations and environmental conditions of the region. In-depth research need to be focused on yield enhancement attributes while making use of locally available natural resources. Also the possibility of marketing of traditional pulses needs to be explored as it is available for Glycine max (Black soyabean). In addition, proper campaigning of traditional pulse in urban market is essential. The government must incorporate the traditional legumes and other crops in public distribution systems (PDS), which will increase the interest of the people towards these crops and will help to counter the bias towards wheat and rice in both domestic consumption and production. This will require awareness among the people about the potential and value of these crops since they are tasty, rich in nutrition and also possesses medicinal properties. Village or community level small co-operatives where collection and processing of raw pulses from a particular area/region can be done and which can make a direct approach to market is need to be encouraged. This will provide a supplementary job and bonus income to villagers. Since hill economy and agriculture is women folk based, the action to empower them through training in technical, leadership and organization skills can led to successful outcomes from implemented strategies, individual household food security and conserving agriculture diversity.

Owing to diverse ecology, in-situ conservation is the most appropriate measure for legume/agro biodiversity conservation in Himalayan region. For this, suitable regions, which are rich in traditional varieties of legumes and other crops, are required to be identified immediately. A similar step was taken few years back by a team of scientists when they selected few pockets and valleys in the Central Himalaya, which were the hot spots of agro biodiversity. They emphasized on conservation of traditional crops in their natural habitat (Maikhuri et al., 1996; Nautiyal et al., 2005). Central Himalaya represents a strong network of protected areas, (Sanctuary, National parks and Biosphere reserves) many of which are reservoir of cultivated and wild relatives of diverse traditional crops and could be a viable option for in-situ conservation and management of legume and other traditional crops. One possibility is to declare some of them as a legume or agro biodiversity heritage sites under the Biological Diversity Act (Anonymous, 2002).

Future prospects of traditional legume crops for sustainable agriculture and livelihood

As per Uttarakhand state agriculture policy 2001, promotion of organic agriculture is in priority. To enhance organic cultivation the government has planned to take many revolutionary steps like enhancing use of biofertilizers, green manure and vermiculture and collection and nuclearization of waste to produce compost. To achieve the goal establishment of laboratories and research centers has also been proposed. Identification of regions where agriculture is purely organic and declaring them as “Organic Farming Region” is also in the proposal. Legume crops by fixing atmospheric nitrogen improve soil nitrogen and hence can ensure organic farming while meeting the state’s food security needs. As a small step toward this the government has planned to provide Rhizobium inoculation facility to the farmers to increase soil nitrogen content. Legumes also led subsequent crop to grow organically by increasing the soil fertility. Thus involving legumes in agriculture will have twin benefits i.e. improve soil fertility and provide good quality organic food, which will provide good monetary returns as organic foods are highly demanded in market at increased price (Bose, 2006). To ensure organic farming, besides legume cultivation, there is also a strong need to ban the use of chemical fertilizers, high yielding varieties and promote indigenous seed saving, mixed cropping, reduce emphasis on just two crops i.e. wheat and paddy, enlarging the public distribution system (PDS) basket to include legumes and its associated non-legume crops and local sourcing of PDS stocks to ensure that farmers are given a good prize for their products.

Farmyard manure, which is derived mainly from forest and livestock component, contributes more than 50 % of energy input into hill agro-ecosystems (Semwal and Maikhuri, 1996). But owing to depletion of forest area as well as quality of forest, it has become difficult to collect required amount of organic material (leaf litter) from the forests, which in turn lead to nutrient loss and soil degradation. As far as quality is concern, the partially decomposed material does add more humus to soil than nutrition. So under such circumstances incorporating pulses in agriculture can help to some extent in maintaining soil fertility and would also minimize pressure on existing forest resources.

Conclusion:

Garhwal Himalaya is a hub of complex diversity of plants and crop species, which confer the inhabitants with a multiplicity of food. However, as modern cultivation technologies and concern for monetary gain develops, farmers are focused on only few crop species. The “More Production” approach has amplified the productivity of few crops and breeds and resulted in decline in the status of many other local crops. The “homogenous cultivation and maximum production” approach imperils the traditional crop diversity of Central Himalaya. Some of the hill crops, which are now ignored and neglected among the farmers, are Eleusine coracana, Echinochloa frumentacea, Setaria italica and pulses like Glycine spp. (kalabhatt), Macrotyloma uniflorum, Vigna angularis, Vigna unguiculata etc.

Traditional Himalayan pulses are rich in nutrition and show most promise for providing the increased demand of vegetable proteins that the world will need in the near future (Maikhuri et. al, 1996). Still these crops are never been exposed and disseminated outside their indigenous areas, where they can be cashed. Present study discloses that the status of pulses is declining to such a fast rate that their long-term survival is in doubt and a time will come when the region would loss the traditional knowledge of cultivation and uses of pulses forever and also would loss the opportunity of being a hub of legume crop diversity. This is not the case in Central Himalaya but in international scenario there are many promising pulse crops, which are almost unknown to science (NAS, 1984).

Being a complex interlinked production system of crops, forest and animal husbandry, agriculture in hill area is not adapted to new industrialized techniques. The reasons are topography as well as socio-economic conditions (Maikhuri et. al, 1996). So to restore the sustainability of agriculture and legume crop production a natural resource management based approach has to be developed. The conservation policies suggested in this paper could succeed only if linked with the socio economy of the farmers. Pragmatic multidisciplinary approach is needed, to evolve a sustainable and efficiently productive farming system, which can provide food and economic security to the people without harming traditional knowledge, crop wealth and environment.

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Table 1: General structure of the villages selected for present study in Mandakini valley of Central Himalaya.

Village name	Total population	Total Male Population	Total Female Population	Total geographical area (ha)	Total Agriculture land (ha)	Irrigated land (ha)	Rainfed land (ha)
Badeth	130	55	75	34	15.6	1.5	14.1
Bhatwari	234	99	135	84.3	47.4	1.6	45.8
Malkhi	317	144	173	68.1	38.1	-	38.1
Mandguh	679	306	373	262.7	91.6	0.4	91.2
Jagot	638	308	330	157.9	52.4	10.2	42.2
Kamsal	540	259	281	109.5	44.9	0.6	44.3
Silkote	55	28	27	45.4	7.9	2.7	5.2
Sauri	179	93	86	23.1	11.9	4.7	7.2
Dobha	307	157	150	26	21	0	21
Khaliyon	100	44	56	47	16	0	16

- Source: Population census 2001, Block office Agatsyamuny, District Rudraprayag, U.K. Govt.

Table 2: Area (hectare/village) under rainfed cultivation of some prominent cultivated legumes at two points of time (1980 and 2005).

Crop	Area under cultivation (ha/village) 1980	Area under cultivation (ha/village) 2005	% Decline/increase	Reasons for Decline/increase
Macrotyloma uniflorum	1.8 ±0.07	1±0.10	44	Decline in monoculture practice, Reduced proportion/density in mixed cropping.
Vigna angularis	2.5 ±0.14	2.1 ±0.11	16	Reduced proportion/density in mixed cropping, shift towards cash crops.
Glycine spp.	1.6 ±0.15	0.4 ±0.02	75	Replacement by soyabean.
*Glycine max**	0.1±0.035	1.8 ±0.08	94	Legume introduced.
Cajanus cajan	2.2 ±0.13	1.9 ±0.1	13	Decline in monoculture practice, Replacement by stable crops and soyabean.
Vigna mungo	1.2 ±0.05	1 ±0.11	16	Reduced proportion/density in mixed cropping.
Vigna unguiculata	1 ±0.03	0.81 ±0.03	19	Reduced proportion/density in mixed cropping.
Lens esculenta	0.81 ±0.05	0.24 ±0.01	70	Replaced by high yielding varieties of wheat.

Pisum sativum	0.81 ±0.02	0.32 ±0.005	60	Replaced by high yielding varieties of wheat.

***** The area has increased, ± indicates standard error (s.e.)

Table 3: Per unit area grain yield (kg/ha/year) of some prominent cultivated legumes and associated crops under mono and mixed cropping at two points of time (1980 and 2005) in Central Himalaya

(A) Kharif season legume crop grown under mono cropping	**Grain yield (kg/ha/yr) 1980**	**Grain yield (kg/ha/yr) 2005**
***Macrotyloma uniflorum* (LC)**	900±47.0	740 ±41.2
***Vigna angularis* (LC)**	1100 ±61.2	1020 ±57.9
***Glycine spp.* (LC)**	1300 ±65.2	NC
***Glycine max** (LC)**	NC	1400 ±47.4
***Cajanus cajan* (LC)**	1050 ±59.2	900 ±46.4
***Vigna mungo* (LC)**	870 ±40.9	730 ±27.2
(B) Kharif season legume crop grown under mixed cropping		
***1. Macrotyloma uniflorum* (LC)** +	110 ±5.7	70 ±6.9
***2. Vigna angularis* (LC)** +	190 ±3.5	160 ±6.3
***3. Glycine spp.* (LC)** +	120 ±7.1	50 ±5.5
***4. Glycine max** (LC)** +	10 ±1.4	68 ±5.5
***5. Cajanus cajan* (LC)** +	200 ±8.4	150 ±7.1
***6. Vigna mungo* (LC)** +	140 ±11.4	100 ±6.9
***7. Vigna unguiculata* (LC)** +	110 ±7.9	80 ±6.1
***8. Amaranthus viridis* (NLC)** +	100 ±7.2	10 ±1.5
***9. Eleusine coracana* (NLC)** +	2150 ±50.0	1750 ±80.6
10. Others (NLC)**	32 ±2.2	15 ±1.4
Sum	3162	2453
(C) Rabi season legume crop grown under mixed cropping		
***1. Lens esculanta* (LC)** +	18 ±1.1	5.4 ±1.0
***2. Pisum sativum* (LC)** +	23 ±0.7	9.2 ±1.1
***3. Triticum aestivum* (NLC)** +	2200 ±68.9	1750 ±41.8
***4. Brassica compestris + Hordeum vulgare* (NLC)**	100 ±6.7	40 ±4.5
Sum	2341	1804.6

± indicates standard error (s.e.) Do we have any scientific assessment of 1980 to give SE values ?

Table4: Population census of studied villages during 1981, 2001 and approximate migration rate during 2001

Village	Population 1981*	Population 2001*	Approximate Migration %	Population 2001 (After migration)
Badeth	**101**	**130**	**8**	**120**
Bhatwari	**215**	**234**	**44**	**103**
Malkhi	**271**	**317**	**23**	**243**
Mandguh	**632**	**679**	**14**	**584**
Jagot	**472**	**638**	**21**	**501**
Kamsal	**478**	**540**	**11**	**482**
Silkote	**43**	**55**	**18**	**45**
Sauri	**85**	**179**	**10**	**161**
Dobha	**238**	**307**	**28**	**222**
Khaliyon	**73**	**100**	**27**	**70**

* Source: Population census 1981, 2001, Block office Agatsyamuny, District Rudraprayag, U.K. Govt.

Table 5: List of some important traditional legume crops of central Himalaya with their brief agronomic practices, uses and ethno medicinal properties.

Botanical, English, vernacular name and cultivation altitude	General agronomic description	Uses and Ethno medicinal values
***Vigna mungo* (L.) Hepper** Blackgram Urd or kali dhal 500-1750masl	Both mono as well as mixed cropped with other associated seasonal leguminous and non-leguminous crops in rainfed agriculture. In irrigated land it is grown on the bunds of paddy field.	Grains are either cooked into dhal or grinded into powder to prepare a local dish called *chainsa*, usually served with cooked rice. Grain powder or boiled grains are used to prepare stuffed *paranthe (*a form of *chapatti).* Being considered sacred, *urd* has wide roles to play in prayers and other rituals. Overnight water soaked grains are processed into *pakodi (*a local dish*)*, which is an important component of prayers in birthdays, marriages, festivals and other functions. When young child is weighed in birthday, raw *urd* is an important component of the material being offered against child weight. While fasting on

		Saturday, *khichdi* is prepared which is a mixture of black gram and rice. When mixed with water, grain powder has a sticky property and forms hard covering when dry and thus was used to re-fix fractured bone by local medical practitioners earlier. Grain powder was also mixed with a locally available lime and other coloring and housing material as an adhesive in the past. The famous clock tower and floor of Royal court in Tehri are made of urd powder. After thrashing husk is given to cattle.
***Vigna angularis* (Willd.) Ohwi and Ohashi** Adjuki bean Rains or nanni dhal 1000-2250masl	Primarily a rain fed crop but also cultivated on the bunds of irrigated land along with paddy. Monoculture is seldom practiced and generally cultivated in mixed form with other seasonal crops.	Young and succulent pods are eaten raw. Grains are consumed as dhal and used to prepare *paranthe* and *pakodi* in the same way as *urd*. The seed coat left after *pakodi* preparation is given to cattle. Boiled seeds are prescribed in jaundice. After thrashing, the plant husk is given to cattle.
***Glycine max* (L.) Merrill** Black Soyabean Kalabhatt 1000-1600masl	Sown in late June and harvested in November. It is generally mixed crop. At some places it is also cultivated on the bunds of paddy field.	Consumption as dhal is very rare. Generally processed into *Bhatwani* a preparation from partially grinded grains and served with cooked rice. In winters roasted seeds are eaten to maintain body heat. Grains in the form of cattle feed is given to cattle which increases milk production. Mature plant after grain thrashing is considered as a nutritious fodder. Seed paste is applied on skin to cure skin infection.
***Macrotyloma Uniflorum* (Lam.) Verdc.** Horsegram Gehet 600-2000masl	Both mixed and mono cropped in rainfed agriculture. Undergoes germination very easily under less availability of soil moisture. Grains are prone to insect attack when stored.	A delicious hill pulse. Grains are consumed as dhal or processed into "*fana*" a local preparation from overnight water soaked grains. Boiled grains are processed into stuffed *paranthe*. Generally consumed in winters as it provides heat and maintains body temperature. It provides high

		calories and energy to people engage in physical work. In traditional therapeutic system dhal soup is consumed to dissolve kidney stone. Its potential can be assessed by the fact that in the past *Gehet* was boiled and its water was poured into huge stones with force to break them.
***Vigna unguiculata* (L.) Walpers** Cow pea Sonta 500-1750masl	A rainfed, rainy season crop, mixed cropped with other associated seasonal crops. Monoculture is very rare.	Grains are consumed as dhal, or processed into stuffed *paranthe* and *pakodi* like *urd.* Boiled dhal without salt is used to treat chicken pox (*Dadra).*
***Cajanus cajan* (L.) Huth** Pigeon pea Tor 500-1650 masl	Both mixed and mono cropped in rainfed agriculture. In mixed cropping it is an important component as its strong stem provides support to other associated climbers. Due to good market demand, high yielding attributes and importance in ceremonies it is mono cropped to a large extent. The crop possesses good resistance against weather uncertainty and thrives well under drought as well as heavy rain conditions compared to other crops.	One of the most prolific cash crop. Its dhal is an important menu of marriages and other ceremonies. Also consumed in the form of *chainsa,* a preparation from partially grinded grains. After final harvesting the plant is given to cattle and the dried stem is used as fuel.
***Phaseolus vulgaris* L.** Rajma Chhemi 1500-2500masl	Essentially a crop of higher Himalayas where it is a prolific cash crop. Garhwal Himalaya particularly the Joshimath (Niti valley) and Harsil (Gangotri valley) regions are famous for its good quality and wide varieties of *P. vulgaris*. Generally mono cropped but mix cropping with potato and *Amaranthus* is also frequent. To provide support to the crop for	Very famous as dhal with in and outside the Himalayan region. Green pods are consumed as vegetable. Though it has medicinal uses in ayurveda but those are not known to villagers.

	climbing, stem of Ringal (*Thamnocalamus*) is used at some places. The crop is prone to insect attack and ash spraying is locally practiced to protect crop.	
***Glycine max* (L.) Merrill** White Soyabean Safed Bhatt 700-1700masl	An introduced cash crop and both mono and mixed cropped to a large extent owing to high market demand.	An important prolific cash crop. Either sold or exchanged with other food commodities. Consumed as dhal in combination with other pulses. Grain in the form of cattle feed is given to cattles.
***Pisum arvense* L.** Wild pea Kong 2200-2642masl	A crop of higher altitudes, generally mixed cropped with cultivated pea. It is a wild relative of cultivated pea.	Grains are consumed as dhal.
***Pisum sativum* L.** Cultivated pea Matar 500-2642masl	At low altitudes it is either confined to kitchen gardens or mixed cropped with wheat. At high altitudes it is mono cropped.	Green and succulent pods are either eaten raw or consumed as vegetable. Grains are consumed as dhal. It is an important cash crop of higher altitudes.
***Vicia faba* L.** Broad bean *Shivchana* 500-1500masl	A rabi season vegetable pulse crop cultivated mainly in kitchen gardens as monocrop. Cultivation on the bunds of *Allium* field is also practiced at some places.	Young pods are processed into vegetable. Grains are consumed as dhal.
***Lens esculenta* Moench** Lentil Masoor 500-1500masl	A rabi season crop, mixed cropped with wheat.	Grains are consumed as dhal.

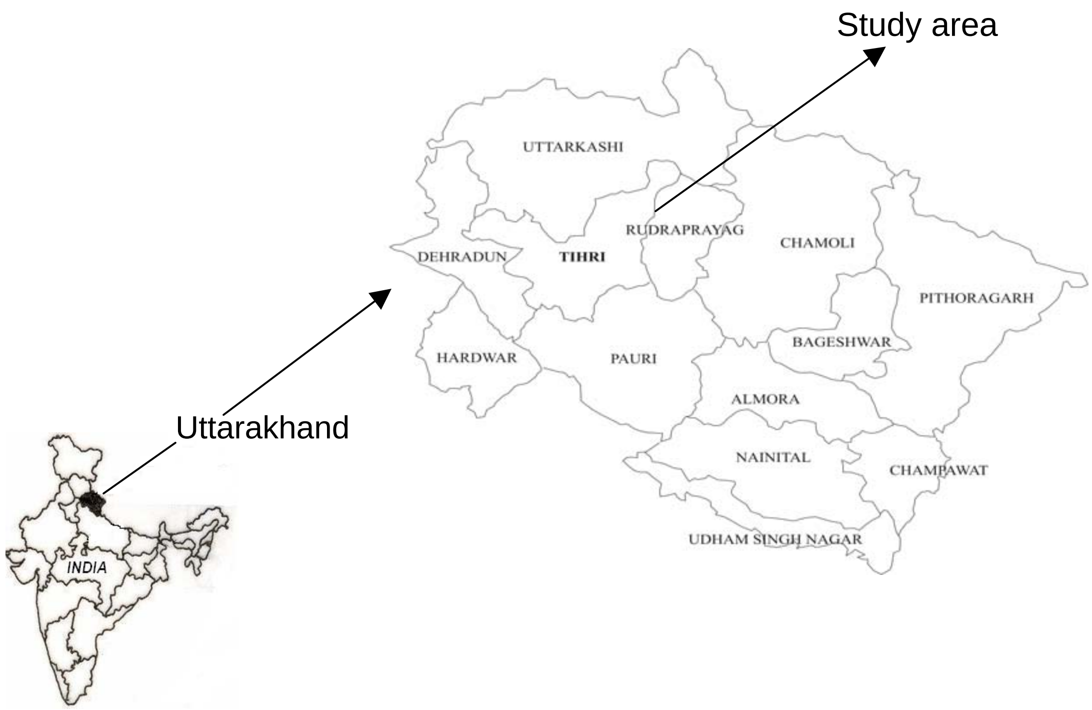

Figure 1: Outline map of The Central Himalayas and study area, India.

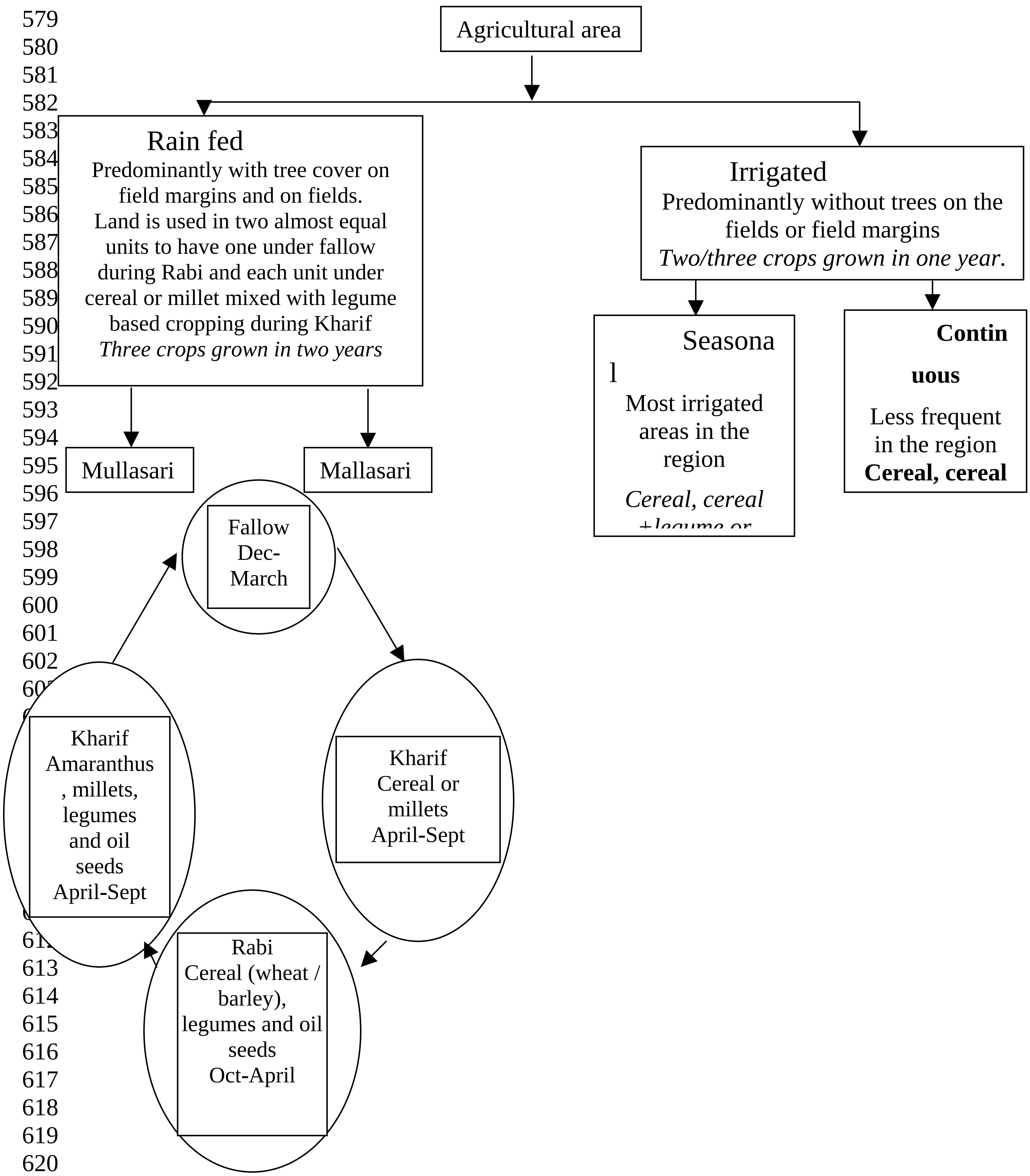

Figure 2: Legume crop cultivation (cropping pattern, crop composition and crop rotation) in the traditional Himalayan rainfed agro-ecosystem.

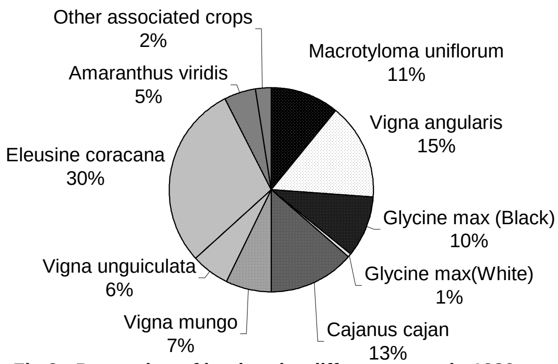

Fig 3a:Proportion of land under different crops in 1980

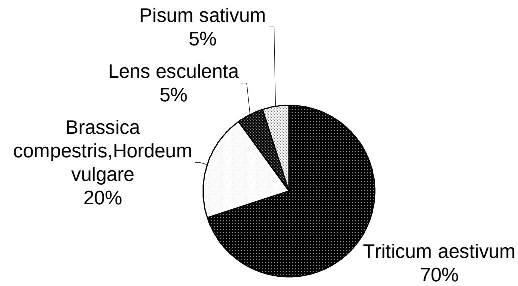

Fig 3c: Proportion of land under different crops in 1980

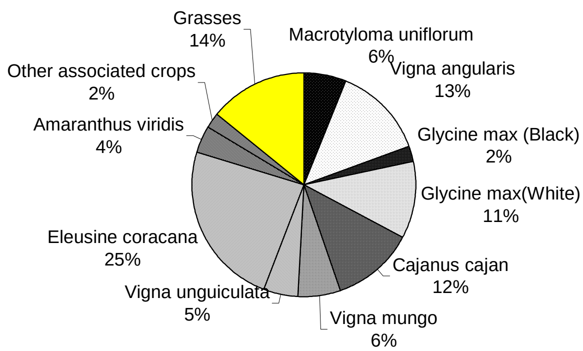

Fig 3b: Proportion of land under different crops in 2005

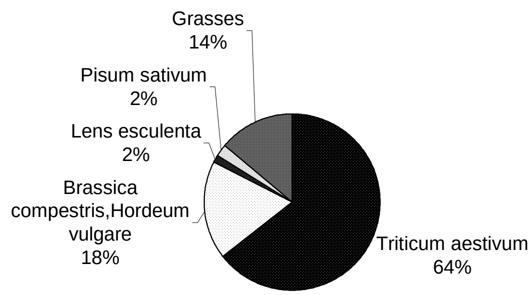

Fig 3d: Proportion of land under different crops in 2005

Figure 3a, 3b, 3c, 3d: Proportion of land under different crops (legumes and associated non-legumes) at two points of time (1980 and 2005) during Kharif and Rabi seasons in traditional agro-ecosystems of the Central Himalaya.

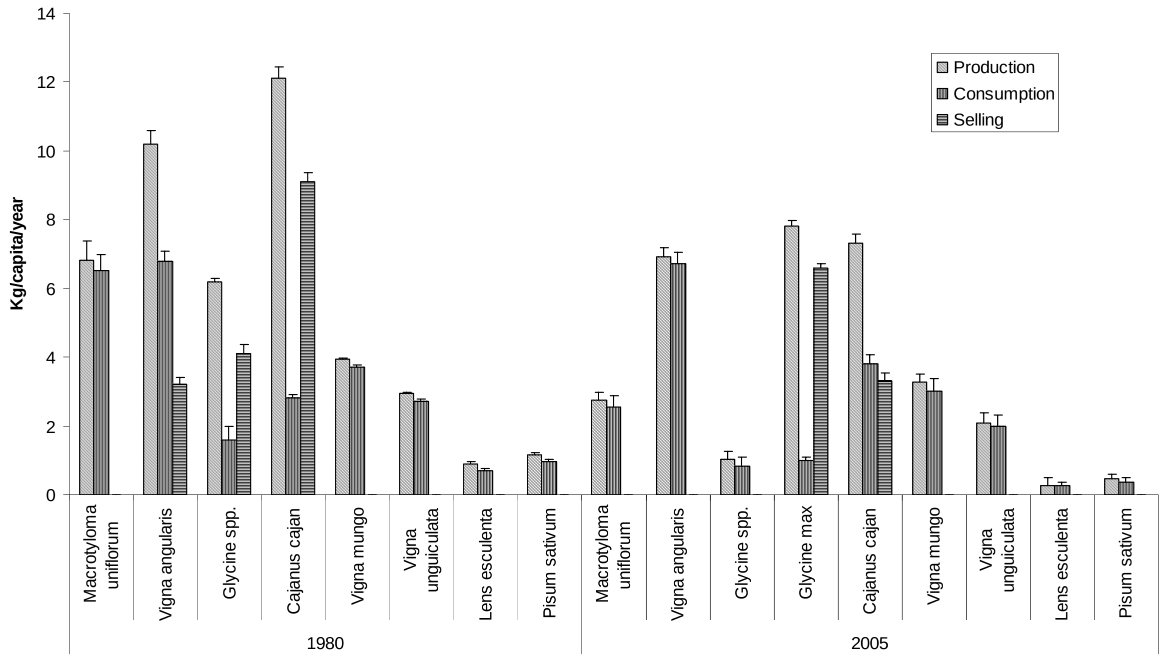

Figure 4: Production, consumption and marketing (Kg/capita/year) of selected traditional legume crops at two points of time (1980 and 2005) in the studied villages of Central Himalaya