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Traditional Agroforestry System: A Case Study from District Chamoli of Garhwal Himalaya

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Abstract: The traditional agroforestry land use system in Indian Himalayan region is an integral part of the society and local environment as in that the crops, animal husbandry and forests constitute interlinked systems. But due to variety of factors the land use under traditional crops is changing very fast in a part of Indian Himalayan region. The present case study explored traditional agroforestry practices among the villagers' in three temperate villages situated in forested sites in Bandwara, Mandal and Khalla in the Mandal area, Chamoli District, Garhwal Himalaya. Although the literacy rate in the villages was quite high, due to lack of employment opportunities people still invariably depend on forests for their livelihood and most of the people were unemployed. Agriculture (which is rainfed in all the study sites) and employment as laborers were the main occupations of people and dairy farming accounted for a major portion of total household income. Average land holdings were low and output from the agricultural land was also low. In general there was reduction in yield from agricultural fields.

Key words: Rainfed · Traditional agroforestry · Land holding · Income sources · Garhwal Himalaya

INTRODUCTION

The Indian Himalayas represent 18% of the India's land area. The Indian Himalayas occupies a special place in the mountain ecosystems of the world. This region is not only important from the standpoint of climate and as a provider of life, giving water to a large part of the Indian subcontinent; but it also harbors a rich variety of flora, fauna, human communities and cultural diversity [1]. Dispersed small settlements and terraced agricultural fields carved out of the hill slopes for raising crops, with numerous multipurpose tree species growing, particularly on the boundaries of rainfed terraces, are typical features in the temperate area of Garhwal Himalaya. Uttarakhand state forms the major part of the central Himalaya that comprises diverse agroforestry system [2,3]. The major land uses characteristics are forests, agriculture, seral grassland and alpine pastures. These land use components are independent [4] over a period of time local people have evolved agricultural practice to meet their food, fodder and fuelwood requirement. The land holdings are mostly marginal (<1 ha) (70% of all holdings) and small (1 - 2 ha). In addition the holdings are scattered at various locations within a village.

Agroforestry practice in the Garhwal Himalaya is permanent feature of Agricultural Landscape [5-8]. However this system is practiced in unplanned manner, farmers have little choice in selection of plant species whatever grows naturally is accepted [9]. The farmers have integrated crops, trees and animals in their farming and land management systems reasonably for solving the problem of acute shortages of fuel wood, fodder and other produce [10]. Small holder farming system in the Himalaya region face constant pressure of change brought about by social, demographic, economic and technological hardship. Mountain agroforestry systems are very

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complex which needs better skill and response to meet and fulfill their various basic needs particularly food and cash crops. Mountain inhabitants by and large face with the widening gaps of demand and supply of basic needs i.e. fodder, food, fruit, fuel timber and related land based products besides other problems of subsistence. One of the basic reasons for this kind of unsustainable growth and development of mountain farming system has been the improper land use technologies development in isolation over time without considering the diverse needs of hill ecosystems [11]. These systems present variety of land holders, having diverse and fragmented land holdings, small scale subsistence or near subsistence farm communities dominate hill farming. Since the scientific information on mountain agroforestry systems have been disproportionately lower in view of the general perception that they are low productive, these systems are seldom debated in policies for their improvement despite providing sustenance to a large section of society. It is therefore, highly desirable to take up a comprehensive study regarding the traditional agroforestry systems practiced in the Garhwal Himalaya along with those that were adopted in recent past in the Garhwal region.

MATERIAL AND METHODS

The study area lies in the temperate zone of Garhwal Himalaya in Uttarakhand State in India (Fig. 1). The study was carried out in three villages viz Khalla, Mandal and Bandawara of Block Dhasoli in Chamoli district of the Garhwal region which lies at latitude 300 27.560'N and longitude 790 15.234'E between 1500 m and 1550 m. Mean annual maximum temperature was recorded as 16.41 ± 3.60°C, mean annual minimum temperature as 6.14 ± 1.98°C. Mean annual rainfall was recorded as 2044.47 ± 476.01 mm. The climate in the study area can be divided into three distinct seasons; cool and relatively dry winter (November to March); warm and dry summer (mid-April to June); rainy (July to mid-September). The rainfall pattern in the region is largely governed by the monsoon rains (July-September), which account for about 60-80% of the total annual rainfall. The vegetation in the study area is both natural and man-made. Mandal, Khalla and Bandawara villages are situated at the base of natural temperate mixed broad-leaved forests. Structured and pretested questionnaires were used to interview approximately 25% of the total households in each village (a total of 75 households in 3 villages). Based on the formats devised for conducting household survey in study site, information was collected by undertaking door to door survey based on crops cultivated and cropping patterns. Data collection from secondary sources has also been made to validate some of the information and to supplement the data on demographic aspects. Secondary information was collected from different government and non government offices. The head of each sample household was interviewed. The data collected was primary and secondary nature, the data of primary nature includes livestock information, information on fruit trees, production and consumption of the agricultural products, consumption of fodder and fuelwood in three villages. The data collected of secondary nature involves, information regarding access to facilities such as schools, bus services and LPG distribution centers, type of roads and land utilization, demographic profile of the villages, location and distribution of villages. In addition to this dependency of the families on forests for fuel wood, timber, fodder etc. Data were collected on quantity of fuel wood, fodder, consumed during the year.

RESULTS

Socioeconomic Observations: The literacy rate of the villages was 90% for both males and females and most of the people were educated above 10 grades in all three villages. Although the literacy rate was very high, most people were unemployed because of a lack of employment opportunities. Few people were uneducated and most of those were older. The villagers therefore still relied for their sustenance on rainfed agricultural land and forests. Approximately half of the houses in all the villages were made of cement and the rest were a traditional type made of slate (pathals), wood and straw. Mainly traditional stoves (chullhas) with smoldering fuelwood were used for cooking. Because of the smoke produced by fuelwood and lack of proper ventilation in the houses, women generally face problems of suffocation and suffer from swollen eyes, loss of vision, bronchitis and tuberculosis.

Cropping Pattern: The cropping system in three villages is rainfed and traditional. Three land use cover types were identified, settles farming, forest land and barren land. The cropping pattern were built around two major cropping seasons locally referred to as Kharif (rainy season) and Rabi (winter season). Rice (*Oriza sativa*), finger millet (locally called as Mandua, *Elusine coracana*), soybean (*Glycine max*) and beans (*Phaseolus radiatus*) were dominant rainy season crops. Wheat (*Triticum aestivum*), Jau (*Macrotyloma uniflorum*) barley (*Hordeum vulgare*) and rape seed (*Brassica campestris*)

Table 1: General agricultural details for the study area

Cropping pattern for the study area		
Ravi (Winter season crop)	Kharif (Rainy season crop)	Common leguminous crops
Wheat (*Triticum aestivum*	Rice (*Oriza sativa*),	Black gram (*Vigna mungo*)
Jau (*Macrotyloma uniflorum*)	Finger millet (*Elusine coracana)*	Kidney bean (*Phaseolus lunetus*)
Rapeseed (*Brassica campestris*)	Soya bean (*Glycine max*)	Pea (*Pisum sativum*)
Barley (*Hordeum vulgare*)	Beans (*Phaseolus radiatus*)	Horse gram (*Dolichos uniflorus*)

Agroforesty tree species (planted on the bunds and boundaries of agricultural fields): *Querecus leucotrichophora*, *Grewia oppositifolia*, *Celtis australis*, *Ficus roxburghii*, *F. glomerata*, *Bauhinia variegata*, *Toona ciliata*, etc.

Table 2: Total agronomic yield in study site

Food products	Bandawara			Mandal			Khalla		
(Tonnes)	Rice	Wheat	Mandua	Rice	Wheat	Mandua	Rice	Wheat	Mandua
Production	14.82	14.82	0.98	12.29	8.83	1.45	10.43	9.41	1.31
Consumption	488.64	455.79	243.91	887.86	1087.15	568.48	990.063	1098.65	275.94
Deficit	473.82	440.97	242.93	875.57	1078.31	567.02	979.633	1089.23	274.62

Table 3: Fruit trees found in three villages

S. no.	Botanical name	English name	Local name	Family
1	*Citrus aurantifolia*	Sour lime	Kagzinimbu	Rutaceae
2	*Citrus pseudolimon*	Hill lemon	Pahari - Nimbu	Rutaceae
3	*Citrus sinensis*		Malta	Rutaceae
4	*Juglans regia*	Walnut	Akhrot	Juglandaceae
5	*Morus alba*	White mulberry	Shatoot	Moraceae
6	*Prunus armeniaca*	Apricot	Khubani	Rosaceae
7	*Prunus persica*	Peach	Aaru	Rosaceae
8	*Punica granatum*	Anar	Pome-granate	Onagraceae
9	*Pyrus communis*	Pear	Naspati	Rosaceae

Table 4: Activity of Villagers in Hindu months

S. no.	Hindu Month	Month	Activity of Villagers
1	Chatt	March - April	Sowing of Rice, Potato and Jangura (*Echinochloa frumentacea*)
2	Bashaik	April - May	Wheat, Jau Harvesting, Harrowing of rice field, Field Ploughing
3	Jaist	May - June	Mandua Sowing, Harrowing of rice field, Dal, Ganth, Soyabean Sowing
4	Aasar	June - July	Harrowing of rice and Mandua field,
5	Sawaan	July - August	Harrowing of rice and mundua field,
6	Bhadu	August - September	Free from the field activity
7	Asouj	September - October	Rice harvesting and field Ploughing, Preparation of field for wheat sowing, fertilizer application
8	Kartik	October - November	Wheat sowing and mandua harvesting
9	Mungseer	November - December	Free from the field, fodder and fuelwood collection
10	Pus	December - January	Free from the field, fodder and fuelwood collection
11	Magoo	January - February	Free from the field, fodder and fuelwood collection
12	Phagn	February - March	Filed preparation for rice Sowing, Fertilizer application, Ploughing Field

were dominant crops of winter season. A plot owned by a family was divided into a number of sub-plots locally called as 'Khet'. A 'Khet' was homogeneous in respect of agricultural crops and management practices. Only one crop species was sown in a 'Khet' during winter season. People cultivate the same piece of land twice a year under rainfed condition as subsistence farming. Before sowing seeds, land is tilled with traditional wooden plough driven by a pair of bullock. In some crops like wheat and rice, inorganic fertilizers such as urea and Di-Ammonium Phosphate are applied. Vegetable part includes potato, tomato, French bean, Kidney bean, etc. Along with traditional crops farmers also grow cash crops such as Malta, Illachi and other horticulture crops. *Triticum aestivum, Oriza sativa, Brassica compestris, Elusine coracana* and mix pulses are main crops for farmers.

Total Agronomic yield for the study area is dissipated in Table 2. Within the context of sustainable mountain agriculture, it is now well acknowledge that horticulture plays a vital role in terms of resource base availability, resource use/ management practices and production flow. On the basis of the primary survey and observation there were only 9 types of fruit trees in the study area. Fruit tree species were enlisted in Table 3.

Livestock: Rearing of animals is an evitable part of their social system. Each family maintains 3-5 animals of indigenous breed i.e. a cow, pair of bullocks, buffalo that are reared on traditional lines. The animal not only provides milk and other products but also serve as drought power in the fields. Animal husbandry and farming in hill regions are complementary and closely interlinked. The animals sought out their own food and were assembled only for milking and to protect from wild animals. In the present setting, cows are stall fed but buffaloes are left for grazing in nearby forest. The ban on grazing by the forest law also imposed problems to the local people. The farmer therefore grows crops, which provide fodder to the animals and the animal dung is supplied to the fields as manure. Over the years the mix crop is changing and the agricultural production is decreasing, therefore the farmers are finding it difficult to keep large number of animals. Since there has been a decline in the supply of organic manure due to reduction in livestock holding sizes, the availability of crop residues have been biggest source of fodder, has drastically reduced after commercialization. The livestock status in the region was poor. Per family buffalo holding in Bandawara, Mandal and Khalla were 1.05, 0.4, 0.6 individuals and cows were 1.65, 1.65, 1.85 individuals and ox were 1.7, 1.2, 1.45 individuals, respectively. The most common species used by villagers and species which villagers preferred through prioritization matrix method are as: among trees *Bauhinia variegata*, *Morus alba, Quercus dilata,* among grasses *Pennisteum purpereum, Cenchrus ciliaris, Debregeasia salicifolia* and *Valeriana hardwickii* and among agricultural residues *Hordeum vulgare, Oryza sativa* and *Triticum vulgare* were considered best in providing best and high nutrient rich fodder for the livestock population.

Pattern of Energy Consumption: Fuelwood is the most common and primary energy source among rural populations in developing countries [12] and is used for cooking and also to heat rooms and water during the winter season. Other forms of commercial energy are beyond the reach of ordinary people because of poor socioeconomic conditions, lack of communication, high prices and limited supply in inaccessible mountain areas [13]. It has been reported that 54% of the total global wood harvest is for fuel [14]. Hence, fuelwood plays a major role in the progression of forest degradation. In all the study villages, 100% of the families use wood as the chief source of fuel for cooking and heating. As all the villages are situated in the temperate zone, where it is usually cold, villagers extract wood for heating and cooking throughout the year. Collection of fuelwood from forests and private lands requires at least 2 to 4 hours of work every day. The villagers travel on an average 2 - 3 km every day to collect fuelwood from the forest. In the study villages, LPG is occasionally used for cooking and mainly for preparing tea or quick food. Other sources of energy used in the area include kerosene oil, which is used mainly for lamps. Other fuel types, such as crop residues and dung cakes, were not used in any of the villages studied. Dung cakes were not used as fuel for 2 reasons: (1) fertilizers are very rarely used in the agricultural fields (except for two crops as rice and wheat) and because dung is the main source of manure, it is therefore required in large quantities; and (2) fuelwood is easily available at no cost and is simple to use compared with dung cakes. Whereas crop residues are either used as fodder or bedding material for livestock, a sod and dung combination constitutes the compost manure for agricultural fields. The economic conditions in the Mandal village are better than other villages. Therefore, the villagers of Mandal area have more capacity to purchase LPG or kerosene and the supply of LPG and kerosene are regular. Also, the Mandal forest is part of the reserved forest; therefore, laws are strictly enforced and extraction of wood is difficult. The most common species used by the villagers and species which villagers preferred through prioritization matrix method are as: *Quercus glauca, Quercus leucotrichophora, Alnus nepalensis, Qurecus dilata, Betula alnoides, Myrica esculenta* and *Rumex acetosa* for fulfilling their fuelwood requirement.

Income Groups: The main occupation in all 3 villages was agriculture, which was practiced at a small scale on terraced farms and was not sufficient to feed an entire family for the year. Few vegetables and fruits from agricultural land were sold on the open market to earn cash income which led to cash crop concept among the villagers. The villagers plant Malta, as a cash crop, but due to heavy rainfall and damage by wild animals in recent years the production of the Malta decreased and which led to have impact on livelihood of local people. Employment as a laborer was the second-largest source of

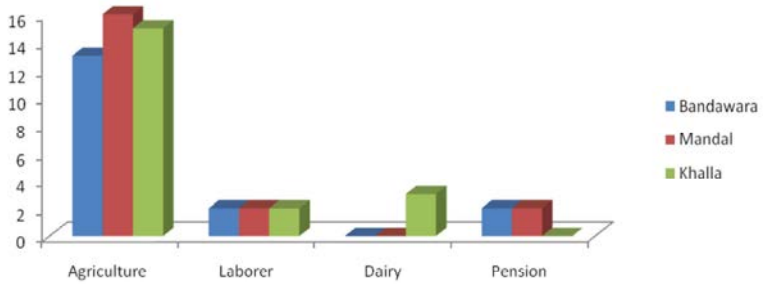

Fig. 1: Showing Different income Groups in Bandawara, Mandal and Khalla

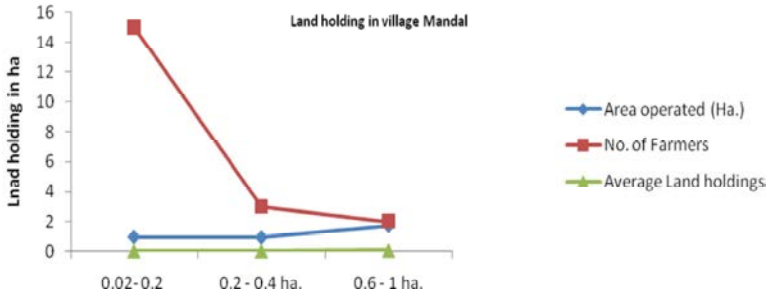

Fig. 2: Showing Area operated, no. of farmers and averages land holding in Mandal

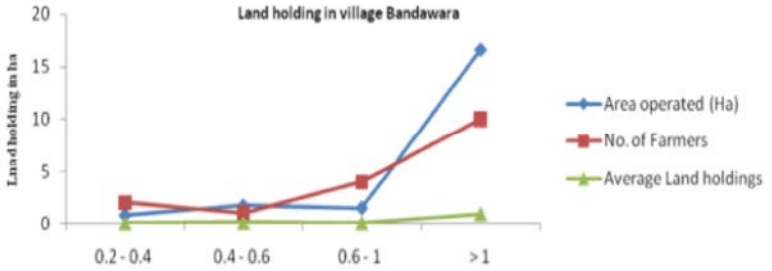

Fig. 3: Showing Area operated no. of farmers and averages land holding in Bandawara.

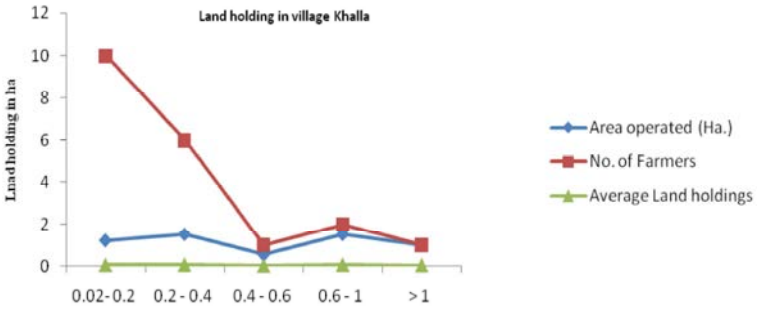

Fig. 4: Showing Area operated, no. of farmers and averages land holding in Khalla

income for the villagers. People worked in Gramin Rozgar Yojna and other welfare schemes run by the government and they sometimes worked as laborers in the private construction sector. Dairy production was the third-largest source of employment in Mandal valley (Fig 1).

Land Holdings: Average land holdings, area operated and number of farmers is shown in below given graphs

Perception about Different Agricultural Problems and Their Remedies: In three different villages, people face problems viz. low productivty from agricultural field,

increase in the rainfall during last 5 years, attack of wild animals such as wild boar, langoor etc damage their agricultural crops, poor quality of soil in their agricultural field and distribution of land creates problem towards agriculture. To overcome with these problems people perception were, development of proper schemes from acting government to enhance agricultural productivity, for protection from wild animals people think there should be proper boundary around their related forest and proper boundary around their agricultural land by the government may result towards their agricultural problems. Some people are in the opinion that modern agricultural facilities should be provided to them.

Fig 4: Showing perception of villagers about Agricultural problems

DISCUSSION

A high level of crop diversity in traditional agroforestry system is maintained through rotation of crops in small fields in time and space together with coexistence of mono - and mixed cropping practices. Traditional values of diversified production system and emphasis on storage of surplus food production in good climate years derived from the necessity of local production based food security in a difficult terrain faced to environmental risks and uncertainties and the concern for fuller utilization of environmental resources [15]. Farmers believe that all agroforestry species have similar effects on all traditional agricultural crops. Proper terracing, drainage, maintenance of protective grass cover on terrace margins and risers, manuring and protection of forest cover around farmland are considered more effective measures for soil conservation and sustainable yields than the role of on farm trees in indigenous knowledge system [16,17].

Now a day's traditional agriculture system does not sustain livelihoods of the villagers. So these systems are decreasing day by day. The farmers are getting low out puts as compared to inputs so they are quitting these agriculture systems. The main reason for this is that agricultural work, sowing and so on is primarily done by women. Agriculture is not seen as a source of income because the probability of crop failure is high, having no monetary value, it is consequently a realm occupied by the women and older men in the village. Raising livestock is the sole responsibility of women, collection of fodder and drying is a perennial chore. In our study, most of the farmers were small, having > 1 ha of land for agricultural production, the present study was supported by Davendra, 2007, he reported that in Asia, small farms are integral to agriculture with an estimated 87% of all farms fall in this category having <2 ha of lands that support 90% of total population characterized by mixed crops-tree-animal systems.

Traditional subsistence farming in the Garhwal and adjoining regions of Himalaya is characterized by settled rainfed agriculture as the major and homegarden as a minor land-use highly dependent on forests for inputs required to produce manure and maintain livestock. Land management objectives have changed with time with changing socio-economic conditions, technological innovations and policy interventions, leading to changes in traditional land-use practices in the Himalaya [17-19] as also elsewhere [20-22]. Farmers of the Garhwal Himalaya believe that yield depressing effects of trees on understorey crops outweigh their yield enhancing effects in tree-crop mixed farming, an element of traditional knowledge also supported by scientific evidences [23,24]. Replacement of traditional crops by altogether new cash crops as a means of economic development [25,26] is visible in the study village possibly because farmers are getting low output from their hard work in the field, but the concept of cash crop is decreasing day by day due to heavy rainfall and damage by wild animals.

The traditional agroforestry practices to some extent have helped people in meeting some of their needs i.e. food, fodder and fuelwood but the farmers with small land holdings and damage by wild animals result in low agricultural production from the unit area. But a modern input in terms of high yielding genotypes into agroforestry is needed if the system is to become more environmentally sustainable.

CONCLUSION

It is important to emphasize that a proper interaction between villagers, agriculture department, NGOs, institutions and government agencies. A proper and people centered approach should be implement in the village according to farmers needs in different sectors. Formulation and implementation of a regional policy should further results better productivity and conservation of agroecosystems.

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