Assessment of anthropogenic pressure, traditional rights and natural resource management issues: a case study of Kedarnath Wildlife Sanctuary, India

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Abstract

The Indian Himalayan highlands are bestowed with many protected areas, including Kedarnath Wildlife Sanctuary (KWLS), where rising pressure on forests is a largely discussed issue. An assessment of anthropogenic pressure in KWLS shows huge dependence of local communities inhabited on forest fringes. This WLS is significant to study as it is under the active consideration to be upgraded as National Park because of unique floral and faunal diversity of great importance. Studies have evidenced of habitat destruction and successional changes in the area because of anthropogenic pressure. Present study provides an integrated approach towards evaluating the biodiversity, conservation and management status of the Sanctuary. Study was based on more than 200 in-depth semi structured interviews and group discussions conducted with forest officials and local inhabitants of six villages. In addition studies related to regeneration pattern and vegetation analysis were carried out in three land tenurial systems i.e. Community forest, Reserve forest and Protected forest. Key issues identified during the discussions included, wildlife offences, encroachment, pressure because of non-sustainable resource harvesting and lack of livelihood opportunities. Regeneration studies showed the continuous change in regeneration patterns largely in the forest patches/stand in side the Sanctuary. Local

level survey stressed on managing Sanctuary fringes considering village economy, social issues, resource requirements and enhancing on-farm based resource production to reduce pressure on forests. Discussion from the forest personals demanded more trained personnel to check encroachment and poaching, being major threat for the effectively biodiversity and valuable resources. Supporting and providing better livelihood opportunities and priority interventions were thought to be viable option for minimizing pressure and managing the biodiversity of the area efficiently through active community participation. This study is helpful in generating useful outcomes and strategies considering viable options through advancing policies for reducing pressure and overcoming management constraints of the Sanctuary.

Key Words: Protected area Management, Wildlife Sanctuary, Anthropogenic Pressure, Natural Resources, Traditional dependence.

1. Introduction

Models of National Parks or Reserves development and management developed in the western countries emphasize preservation and conservation of plants and animals as such areas are the last preserves of representative biodiversity or a keystone species. Studies on the symbiotic interactions among humans, animals and plants from the perspectives of geographers, economist, biologists and botanists (Kacchele and Dabbert, 2002; Nautiyal and Kacchele, 2007). It was realized that, particularly in developing countries, protected area management plans must incorporate and need to provide some economic benefits for the local development and consistent with conservation goals (Eidsvik, 1986; Dasmann, 1982; Misra, 1982; McNeely, 1984; Ramakrishnan, 1992a; 1992b; Bandaratillake, 1992;

Maikhuri et al., 1999; 2001). Such approach has been found successful in managing National Parks and Protected Areas in southern Asia (Saharia, 1984).

Over the past few decades there has been a great concern regarding the ecological degradation and deforestation in the Himalaya. The legally designated Protected Areas (PAs) and other conservation sites in India comprise 614 units, including National Park, Sanctuary and Biosphere Reserve, covering about 7.3% of the total geographical area. The Indian Himalayan Region (IHR) in terms of the uniqueness and richness of biodiversity elements, is represented fairly well (15 National Parks and 59 Sanctuaries covering 9.6% of the geographical area) within the PA network of India (Rawal and Dhar, 2001). Anthropogenic pressure can cause uncontrolled influences that bring changes in floral and faunal diversity, habitat, landscape, soil degradation and may also lead to considerable alterations in the environmental conditions. Livelihood in the rural areas of the mountainous regions depends to a large extent on the subsistence farming. The number of people in India who rely on forests products is assumed to be 50 million (Shiva, 1993). Many traditional societies utilize their natural resource base based on their perceptions, experience and response to patterns of resource uses by others (Samant and Dhar ,1997; Chettri et al., 2006). Economical, indirect and quick benefits from forests are much higher than the direct and sustained benefits. Timber extraction itself to a large extent contributes to the shrinkage in forest cover. There have been studies on natural resources as well as impact analysis of selected National Parks and Sanctuaries on the livelihoods of local inhabitants of the Himalaya (Shah, 1982; Kushoo, 1987; Singh et al., 1988; Kothari et al., 1989; Rawat and Uniyal, 1993; Mishra, 1997; Sharma and Shaw 1993; Nepal and Webber, 1995; Chettri et al., 2006; Rawal and Dhar, 2001). It is

essential to preserve the forests and manage them sustainably to ensure livelihood security of the forest dependent communities and also provide ecosystem services to a larger population. This study aims to explore the existing status and gaps in the conservation and management of Kedarnath Wildlife Sanctuary (KWLS) a globally important conservation area. The main objective of the study is to attest the potential based on a detailed review of biophysical values thorough evaluation of the Sanctuary's conservation status with all stakeholders so as to redefine priorities of biodiversity attributes for future.

2. Study area and Climate

The study focused on Kedarnath wildlife Sanctuary situated in the Garhwal region of Himalaya (Fig. 1). Sanctuary is bounded to the north by a range of places and peaks (30^0 26'-30^0 45' N, 78^0 54'-79^0 36'E) with altitudes range from 1,160 to 7,068 m asl. Area of the Sanctuary according to the original notification, is 96,725.61 ha. and falls under the IUCN management category IV (Managed Nature Reserve) in the biogeographical province 2.38.12 of Himalayan highlands. Biogeographically, the area is in West Himalayan zone of India, which covers the Palearctic realm (Rodgers and Panwar, 1988). Sanctuary harbors nineteen major vegetation types described by Champion and Seth, 1968 in India. The floristic richness of KWLS can be attributed to its location that is at the junction of Indian sub-continent and Indo-China biogeographic regions (Dinerstein, 1997; Prabhakar et al., 2001). For the management purpose the whole KWLS is treated as core zone, and surrounding areas (up to 5 km distance) are considered as buffer zone. The entire Sanctuary lies in the northern catchment of the Alaknanda river, the major tributary of the upper reaches of the Ganges river. The metamorphic rock consists of

gneisses, granites and schists. The main valleys are fully exposed to the summer monsoon, as there is very little rain-shadow effect from the 3,000m-high ranges to the south. Average temperatures are highest in May or June (25^0C) and lowest in first half of January (-10^0C). The Sanctuary is snow-bound for about three months, following heavy snowfall in December (Green, 1983) However, snowfall data were not available so available data for climate are shown in Fg. 2. Due to its rich floral and faunal diversity, core area of 30,000 ha, the Sanctuary is recommended to be upgraded to National Park status (Rodgers and Panwar, 1988) and is under the consideration of Government of India.

3.1 Floral and faunal Characteristics:

The major vegetation/forests of KWLS are categorized into nineteen broad vegetation types based on Champion and Seth (1968) classification. The great variety of vegetation reflects complex and diverse nature of the climate, geology and topography in the region. It is estimated that about 44.4% to 48.8% of the Sanctuary is forested, 7.7% comprises alpine meadows and scrub, 42.1% is rocky or under permanent snow and 1.5% represents formerly forested areas that have been degraded (Prabhakar et al., 2001). A total of 530 species of dicotyledons and 691 species of monocotyledons have been recorded from KWLS (Kala and Gaur, 1982). The area is home to many endangered plant species, *viz. Acer caesium, Nardostachys jatamansi, Picrorhiza kurroa, Podophyllum hexandrum, Saussorea obvallata, Aconitum bulfori* and *A.heterophyllum* (Khushoo, 1991). Sanctuary is bestowed with varied landscape features that provide multitude of habitats to a diverse array of faunal communities. Among fauna some 30 mammalian species, excluding bats, have been recorded and some of them are rare and endangered

such as common leopard (*Panthera pardus* threatened) and snow leopard (*P.uncia)* (Green 1985).

3.2 Agroecosystem in and around forest fringes:

Agricultural lands in each settlement could be divided into two almost equal parts, namely the areas towards hill tops, *Malla Sari*, and the areas down slope from these, *Talla Sari*. All locally called households have plots in both places and may have two cowsheds to prepare Farm Yard Manure (FYM) near to these areas. Though two crops, a summer crop (June-November) and a winter crop (November-April), could be harvested in a year, the tradition is to fallow a Sari during one winter season every two years. However, in high altitude villages (>2000 m asl) Sari system does not exists and only one crop is grown during the summer period. Well maintained orchards of Malta fruit (*Citrus* spp.), *Ficus auriculata* and *Juglans regia* are observed in the villages. Farm area and cropping intensity has changed over the last two decades. Shift from traditional crops i.e. *Eleusine coracana* and *Amaranthus frumentaceus* to cash crop as *Solanum tuberosum* is quite prominent. Cultivation of other traditional crops such as *Echinocloa frumentocea*, *Glycine max, Setaria italica, Panicum miliaceum* and *Pennisetum typhoides* have been abandoned. The area under *Solanum tuberosum* and *Phaceolus* spp. had increased in almost all the villages adding more pressure on forests for floor biomass used for farm yard manure and sticks removal for supporting the legume crop plants.

4. Material and Methods

4.1 Review of historical records:

A detailed review of forest and land use policies for the region was conducted using historical records and government documents. Archival reports related to resource rights,

management and rural development available at various institutes and government departments were studied. The historical records for the Kedarnath Wildlife Sanctuary (KWLS) were gathered from the regional offices of Forest department. The detailed information about demography, settlement patterns and local communities were collected from the office of Revenue department, Ukhimath, District Rudraprayag. Evaluation of the infrastructure, manpower and other support system of the Sanctuary management were carried out through discussions and informal interviews with the Sanctuary officials. Resource rights on forests were also verified from the records of the villages and elected representatives of village institutions.

4.2 Personal observation and data collection:

With the background of the study related to assessment of forest disturbances due to local interferences, three forest stands (each of about 5 hectare) were identified one each falling under the boundaries of Reserve, Buffer zone and Civil forest on the fringe areas of the Sanctuary for in-depth monitoring based on the site-specific indicators of anthropogenic disturbance. In each forest type a minimum of 30 quadrats of 100 sq. m. were laid through stratified random sampling (Misra, 1973; Muller–Dombois and Ellenburg, 1974). In all quadrats all the plants were recorded for their numbers, C.B.H (circumference at breast height) and height. Trees, saplings, seedlings and shrubs were enumerated in 100 m^2 quadrat (Sundriyal and Sharma, 1996). Soil physical (soil moisture content, water holding capacity, texture,) and chemical parameters (soil pH, total organic carbon and total nitrogen) were analysed following standard methodology given by Anderson and Ingram`s Manual, 1989. The Linkages and dependence of the community with the forests was assessed through field surveys by undertaking formal and informal

group discussions and personal interviews with more than 200 local inhabitants (one adult above 25 years of age from each household sampled), and through village survey based on standard tested questionnaire and further data verification with actual field checks. Important village settlements of the Sanctuary and fringe areas surveyed include villages Triyuginarayan, (2400-2600 masl) and Tosi (2600-2800 masl) depend on protected forest for their bioresource requirements, Sitapur (1900-2200 masl) and Rampur (1900-2200 masl) depend on reserve forest and Shersi (1800-2100 masl) depend on community forest. These settlements together have 473 households and a population of 2828. About 60% households of each village were studied regarding their dependence on forests for resource utilization (Table.2). Inhabitants have inadequate production of fuelwood and fodder resources and crops on their farmland. Most of the inhabitants depend on forests for fuel, fodder, timber, NTFPs including medicinal herbs and forest floor biomass particularly leaf litter. The livestock reared by the local communities are in traditional pattern. Information on areas of community interests, encroachment (if any), type of forest products harvested and their concerns/conflicts with the forest officials was collected.

5. Results

5.1 Current Status and Management Implications:

KWLS provides unique habitat to Musk deer (*Moschus chrysogaster)*, Snow leopard (*Panthera uncia)* and other important Himalayan ungulates. Thus, conservation of the KWLS has larger implications not only for India but for whole of south-east Asian regional biodiversity. A comparison of KWLS with major Protected Areas (PAs) of Indian Himalayan Region (IHR) are presented in Table.1. Through informal discussions

with local stakeholders as well as forest officials, it was found that the Sanctuary faces several challenges in terms of external threats associated with irresponsible activities of tourists, infrastructure development and ever-increasing demands for land and water resources by local inhabitants.

5.2 Crop damage by wildlife:

Eleusine corcana, Solanum tuberosum and *Amaranthus frumentaceus* along with the fruit trees are damaged by wild boar (*Sus scrofa*), bear (*Selenarctos thibetanus*), porcupine (*Hystrix indica*) and monkey (*Presbytes entellus*). *Solenum tuberosum* (potato) and *Eleusine corcana* (finger millet) accounted for the maximum loss in the villages near to forest fringes (Table.3). Forest department did not provided any compensation to the local people for crop damage by wildlife. Sanctuary management officials told that local people usually extrapolate and exaggerate their losses so, department is not willing to pay compensation against such losses. Thus, even local people were less interested in making an attempt for receiving compensation against the crop losses.

5.3 Livestock holding and human as well as livestock depredation by wildlife:

Problem of cattle depredation in and around the Sanctuary fringe areas was reported to be high. High altitude villages near to tourist areas like Tungnath, Kedarnath, Madhmaheshwar and at high altitude temporary transhumant settlements showed larger livestock holdings. Horses / Mules were present mostly at high altitude villages but less in numbers at low altitude villages. Sheep and goat populations have declined in high altitude villages during last 20 years (Fg.3). The main reason was of a strict ban imposed by the government on grazing at high altitude alpines that are now part of protected area network. The Chairman of the Village Development Council (VDC) and Chairman of the

Forest Development Council (FDC) need to certify the claim for the killings by wildlife and it is mandatory before the claim. Subsequent verification by veterinary experts was considered by the Sanctuary Directorate for compensation. Only a few claims were settled as the procedure is difficult to implement in the remote area and compensation received by the claimants very less of the total assessed value of livestock lost. People were also less interested to ask compensation for their losses as the bureaucratic procedures are difficult for them to complete (Table.5). In past few years human killings and injuries have also increased in Sanctuary boundaries (Table.4) and compensation paid for the losses are meager against the loss.

5.4 Lack of proper and sufficient infrastructure:

Most of the PAs in Himalayan region lack adequate man power and funds for proper management. Ill-defined boundaries lead to conflicts between the local communities and Protected Area management. The infrastructure facilities for the staff positioned inside the Sanctuary for patrolling and vigilance are not enough in terms of their number. Thus monitoring the area during snowfall becomes difficult because of inhospitable and inaccessible conditions. The northwestern part of the Sanctuary (Madhmaheshwar and Kedarnath-Triyuginarayan area falling under Ukhimath and Guptakashi Forest Ranges) needs more protection as these areas receive tourists to Kedarnath. Also the resource use pressures increases drastically due to immigrant Nepali population engaged in support services to tourists as porters and food carriers stay in the region for six months. There is an urgent need to strengthen the management of the KWLS by allocating well-trained and motivated staff, budget and infrastructure.

5.5 Encroachment inside grazing pastures (Kharak):

Mountain and alpine pastures have traditionally played an important role in the development of livestock population systems in developing countries. Stretches of grasslands and alpine meadows locally called kharak or bughyals, are often found intermixed with the forest vegetation in this region. Other grassy patches (Kharaks) of rather recent origin are being developed due to deforestation, grazing and occasional fires. These grazing areas have been under moderate to high grazing pressure by sedentary as well as by migratory graziers. The carrying capacity of grazing lands in Garhwal region of the Central Himalaya was estimated to be as 3.75, 1.09-3.49, 0.89-1.80 and 0.64-1.18 cows/ha/yr, for sub tropical, warm temperate, temperate and sub alpine and alpine zones (Gupta, 1986) respectively. The carrying capacity of alpine zone of this region as determined (Joshi et al., 1990) was found to vary between 0.60-1.50 livestock unit/ha./year. With a permit of Forest Department, Gujjars, (a transhumant community of Uttarakhand mainly involved with cattle rearing and dairy farming) along with their families and livestock practice transhumance life. They come from Rajaji National Park (their place of their stay winters) to the alpine pastures of the Sanctuary (from April-August) and market of milk products in the tourist areas. Decrease in livelihood options has also led families from near by villages to live in these pastures with their livestock for dairy farming and also practicing short duration agriculture mainly growing vegetables to generate alternate income.

5.6 Dependence on forest resources and poor status of Reserve Forest (RF) and Community Forest (CF) areas:

Fuel wood, fodder and NTFP's collection by inhabitants as well as immigrant Nepali's is varied inside the boundaries of KWLS. Variation in resource collection is correlated to

their social and economic environment and also on the availability of required resources (Table.6). The indiscriminate and unscientific way of lopping of the trees for fodder and fuel wood clearly shows the reduction in the natural forest regeneration and there by the reduction of the ground cover as given in Table. 8. Sampled forests were middle aged forest with CBH of the trees mostly in intermediate girth classes. The forest canopy was dominated by *Q.leucotricophora, Q.floribunda* and its associate species *viz. Lyonia ovalifolia, Rhododendron arboreum, Alnus nepalensis, Myrica esculenta, Prunus cerasoides, etc.* Occasionally *Q.glauca, Aesculus indica, Acer caesium* and *Juglans regia* were also present in canopy sub canopy was of *Neolitsea pallens, Cinnamomum tamala, Betula alnoides, Pyrus pashia, Symplococcs paniculata etc.* The understory was sparse and dominated by *R.arboreum, C.tamala* and sapling of other dominant trees like *Neolitsea pallens, Q.leucotricophora* and shrubs like *Cotoneaster* spp., *Berberis aristata, B.asiatica, Prinsepia utilis, Rosa brunonii, Pyracantha crenulata, Indigofera hetrantha, Vibrnum* spp., *etc.* The mean tree density across PF, CF and RF was 880, 536.13 and 1058.94 individual/ha (Table.1). The highest tree density was recorded for *C. tamala* in RF (522.81 ind/ha), *L. ovalifolia* (323.33 ind/ha) in PF and *A. nepalensis* in CF (149.85). The stand basal area across PF, CF and RF was 78.59, 44.62 and 84.60 m^2/ha (Table).The species with highest basal area across all stands was 24.60 for *Q. lecotricophora*, 13.26 m^2/ha for Lyonia and 23.41 m^2/ha for Q. floribunda. Shanon diversity for PF, CF and RF was 1.34, 1.03 and 1.63. while, concentration of dominance for all three forest types PF, CF and RF was 0.30, 0.52 and00.31 other parameter like trees with no saplings, trees with no seedlings, seedlings with no sapling and sapling with no trees are given in table. While, preferred species for lopping in different categories are similar that depends on the

availability of species in their nearby forest stands. Mean lopping density in PF, CF and RF varied from 296.37 / ha, 576.09 / ha and 36.63 / ha. The resource extraction in different villages depend on nearby forest areas was varied that was majority related to preferable resources present as well as the distance where they were available was feasible everyday to be traveled (Table.7). Fuel wood consumption (Kg/HH) was varied in summer + Monsoon (S+M) and winter months (W) collection was found more during S+M months with less consumption. While, winter months had less collection with more consumption because of snowfall and other factors (Table.9). Consumption in S+M varied from 1187.98-414.62 Kg/HH, while, for winter it varied from 450.96-288.08 Kg/HH. Household size was also an important guiding factor for fuel wood extraction rate. Fodder and forest litter/ floor biomass was dependent on livestock/HH as well as resource availability. Fodder Bojh/HH/Season (1 Bojh= 45 kg) varied from 1485-1072.5 Bojh/HH/Season (40 Kg= I Swalti). Bamboo sticks were used for supporting Rajma (Phaseolus spp) and cucurbitaceae crops as well as preparing storage structures and extraction of Bamboo sticks/HH/annum varied from 316.67-511.5 sticks/HH/annum. While, wild edible fern (Diplazium esculatum) extraction varied from 20.13-12.96 Kg/HH/Season. For soil physio-chemical parameters there is no significant difference among different land tenurial forest system studied ($F=4.67$, $p=0.05$) Carbon content for PF is highest 4.14 ± 0.31 while, for RF it is lower 2.59 ± 0.44. Nitrogen content is also highest for PF=1.34 ± 0.17 while, for RF and CF is almost similar 1.09 ± 4014 and 10.9 ± 0.11. Protected area fringes are more affected in terms of people's interferences where most of the dominant tree species are having less number of seedlings and saplings showing arrested succession and rapid decline in reproduction of these species at present.

Reporting of low carbon and nitrogen content clearly reflects the removal of leaf litter from the forest floor at a fast pace (Table.8). Most preferred fuel wood species are *Q.leucotricophora, Q.semicarpifolia, Lyonia ovalifolia, Pyrus pashia, Prunus cerasoides, Alnus nepalensis* and *Aesculus species*. House structures are semi wooden and *Alnus nepalensis, Prunus cerasoides, Q.leucotricophora, Abies pindrow* etc. are most preferred for the wall material. *Q.glauca, Deutzia staminea* are used for making daily use household equipments. Variety of wild edible plant species, such as flowers of *Rhododendron arboreum,* fronds of *Diplazium esculentum,* fruits of *Myrica esculenta,* bark of *Taxus baccata,* fruits of *Berberis aristata, Rubus ellipticus* are known to be frequently collected by locals of the area. Guchhi (*Morchella esculenta* (aerial part of wild mushroom)) collection is also recorded in the area for their own consumption and for marketing locally as well (Table.10). There is rising shortage of non-wood forest products because of increasing pressure on forest areas. *Thamnocalamus falconeri* and *Thamnocalamus spathiflorus* are frequently used to support crops of cucurbits and legumes and other desired timber and fodder yielding species for various purposes. The extraction of boulders and stones from hills is leading to landslides in the region at an alarming rate (area also faced devastating earthquake in the year 1991). Unfortunately, the forest resources from this region are continuously being degraded (Shah, 1982; Khoshoo, 1987) and continual biomass extraction (i.e., fuel, timber and fodder) is considered a major reason for such depletion (Gadgil et al, 1989; Singh 1988).

5.7 Inaccessibility of terrains for Patrolling:

A very large portion of the Sanctuary is inaccessible for forest guards for regular patrolling due to its steep topographical terrains. Lack of sufficient and well-equipped

forest guards is also one of the major constraint. Local people and Nepali migrants are well aware of the trails and paths inside the forests because of their forays for various purposes (legal as well as illegal). So, protecting the forests and wildlife against their offences sometimes seems to be a tough task for the forest department. The numbers of the forest guards posted inside the Sanctuary are too less to deterr the offenders committing illegal poaching and collection and threat to the existence of wild flora and fauna.

5.8 Inadequate Research and Development Status:

Present status regarding R and D information is still inadequate and insufficient. Most of the research work is individually done by few organizations. During the discussion with forest department it was found that there is need to undertake research on various aspects of regeneration, species association, standing biomass and annual productivity assessment, phenology and quantification of community demands and their interference and pressure inside as well as in the fringe areas of Sanctuary. Since this is unique site for long-term studies permanent plots can also be set for long-term floristic and climatic change studies that can definitely provide a platform for long-term management of the Sanctuary with respect to global climate change scenario.

5.9 Policy issues:

The basic approach to management of Protected Areas (PAs) has been isolationist, based on the questionable assumption that we must protect the area from people living in surrounding areas and shield wildlife and other resources from exploitation. But the needs and aspiration of rural people living in and around them are largely over looked when the conservation policies are implemented. This implementation is achieved through a strict

enforcement of legislation, patrols to prevent illegal activities and infrastructure maintenance. In such scenarios, attempts to protect PAs from human intervention by coercion have often led to hostile attitudes of local people towards wildlife management and forest staff, sometimes to open conflict as observed in some parts of the Sanctuary. Conflicts in the Sanctuary are mainly linked to harvesting of NTFP's and loss of their extended resource use rights after the declaration of the area as protected. Human dimensions in the Sanctuary, including the other PAs of IHR (Indian Himalayan Region), assume great priority because of the present scenario that states the global change in the mindset of the policy planners who have come to realize that conservation issues inside the PAs cannot be dealt without participation of traditional societies/ethnic groups that have occupied the place for millennia (Rawal and Dhar, 2001; Maikhuri et al., 2000; 2001; Rao et al, 2003). This has led to the recent focus of policy planners on the need of people-responsive strategies for the conservation in the PA network of IHR resulting in strengthening of the buffer zone concept. The Sanctuary management and administration ought to involve local people by taking them into confidence in planning as well as in decision-making. This will also reduce the circumstances for conflict issues and help in conflict resolution with regards to resource extraction wherever in practice.

5.10 Eco-tourism option for economic development:

Sanctuary is rich for its rare scenic forests with high ecological, cultural, religious, spiritual values and rich bio-diversity and has a long history in attracting nature lovers or eco-tourists. But the major emphasis is all upon the regular pilgrimage visit to Kedarnath, Tungnath, Rudranath, Trijuginarayan etc. shrines. There have been very little efforts made so far towards development for eco/village based/rural tourism promotion in the

area as most of the trails and roads connecting these villages are fragile and poorly maintained. Yet, the potential of eco-tourism to help conserve these precious biodiversity and assist in economic development remains largely untapped in this Sanctuary. However, forest department is very keen towards developing this region as a potential site for eco-tourism and programme facilities has been designed in this regard by local development committee. While, promoting eco-tourism the critical factors that directly or indirectly affect the carrying capacity need to be taken in account along with the identification of limiting factors such as period for eco-tourism activity, cultural, religious, ecological and biological conditions including visitors' behavior patterns and their perceptions (Maikhuri and Rao, 2005)

6. Discussion

6.1 Conservation and Management strategies:

In Himalaya, comparable conflict developed as colonial governments appropriated forests from local communities to promote scientific forestry (Guha, 1990; Peluso, 1992) Similarly, the creation of National Parks and protected areas has led to the removal of local inhabitants and/or their exclusion from traditionally used natural resources (Maikhuri et al., 1999). Maikhuri et al., 2001 have also claimed that biosphere reserves are surrounded by people who were excluded from the planning of the area, do not understand its purpose, derive little or no benefit from the money poured into its management and hence do not fully support its existence. Although, in the beginning protected areas excluded local communities, revoked customary rights and banned local people for illegal incursions into protected areas in the 1980’sand 1990’s, local people came to be recognized as an integral part of the conservation area. This led conservation

practitioners to develop alternative models of protected area's management that addressed conflict between local people and protected area managers while portraying local development and participation of local community as essential components of the conservation. The strong linkages between the management of protected areas to the economic development and participation of local communities were explicitly advocated (Maikhuri et al., 2000; 2001). Protected area makes a vital contribution for the conservation of the social, natural and cultural resources. They are essential for conserving biodiversity and for delivering vital ecosystem services, such as protecting watershed and soils and shielding human communities, especially indigenous people who depend for their survival on a sustainable supply of resources from them. Sanctuary area can provide options for rural development, rational use of marginal lands, monitoring for conservation education and for recreation and tourism. After the declaration of the area as a Sanctuary several decisions and plans have been prepared to conserve the habitat, wildlife and related natural resources in KWLS. Still there are few issues and challenges that need to be answered precisely viz. lack of awareness building regarding the concept, idea and their role in protecting and sustainably using the resources among the local inhabitants of the area, disintegration of traditional village-forest institutions of the area, need of the continuous facilitation of local inhabitants for sustainable use of the resources are certain implications. Through discussions various questions emerged in relation to growing population and their needs for survival, lack of employment opportunity, options for better livelihood, people-policy conflicts over access to resources, lack of collaboration, coordination among the stakeholders for management of resources etc. were the important issues identifies that needs to be appropriately addressed for future

interventions. People's dependence on fuel wood as a primary source of energy was thought to be causing serious deforestation in many developing countries (Pasca, 1981; FAO, 1982; Kartawinata and Rayda, 1984; Eckholm et al., 1984; Fox, 1984; Ramakrishnan, 1987) and is found responsible for environmental problem that forest clearing brings. In the context of natural resource utilization Gadgil, et al. 1989 have estimated a demand of 1.8 million tones of fuel wood for Garhwal and Kamaun part of IHR. This increasing pressure can be attributed to some downshift in management of the Sanctuary due to various reasons and could be easily tackled by strengthening staff and infrastructure through policy modifications and community participations and afforestation in wastelands and agro-forestry system. Although, forest department officials undertake periodic census in selectively logged forests yet, such investigation is generally aimed to document the regeneration of commercially important species and not to analyze the changes in the compositional and structural aspects of other associated species. Thus, to provide the fundamental knowledge required to undertake sustainable management of the forests, both silviculturally and ecologically, more precise studies are needed to clarify the effects on overall stand structure and floristic composition and may help to address the issues of human pressure and conflicts over access to natural and traditionally used resources. If forests are continuously subjected to selective logging before they resemble a primary forest both structurally and floristically, they would experience arrested succession and resultant vegetation would be dominated by the late secondary or early secondary species depending on the severity of the disturbance and it was apparent well in case of vegetation sampling done in three forest land tenurial systems. Unwanted settlements inside the boundaries of the Sanctuary also need to be

rehabilitated properly as their dependency on forests is more than other household of the near by villages. Scientific studies particularly on resource extraction, supply and demand will be very useful in understanding the complexity of the system and designing the effective conservation programme for management of alpine pastures (Kala, 2004). Therefore, the sustainable development of protected areas, rather than applying general plans or very general recommendations for socioeconomic development of the people and regional conditions need greater emphasis (Flamant et al., 1999; Kacchele and Dabbert, 2002). This issue can be resolved by mutual agreement between the village people and forest authorities (Nautiyal and Kaechele, 2007). Nautiyal, 1998 and Maikhuri et al., 2001 discussed various aspects of management for NDBR which include people's perceptions and attitudes towards conservation policy and related management interventions, nature and magnitude of policy people conflicts and possible options for conflict resolution which include medicinal plants cultivation, value addition in wild edibles and traditional agro-biodiversity, eco-tourism promotion, rehabilitation of degraded lands through native MPTs preferred by local communities. All these interactions were demonstrated on smaller scale following long term scientific, participatory and action research approaches (Maikhuri, 1998; Negi, 2002; Nautiyal, 1998). These success stories need to be replicated according to site-specific problems. Conservation and management would be more effective and feasible if system function and structure related to core National Park and buffer zone are perceived in a comprehensive holistic way integrating social and biological relations and dependencies (Hjortso et al., 2006). The integrated approach considering ecosystem complexity in view is a more feasible and supportive approach for enhancing economics, maintaining natural

capital and continuing to provide ecosystem services on a local, regional and global scales (Noordwijk et al., 2001) rather than the segregated unidirectional way for biodiversity conservation.

7. Conclusion

7.1 Incentives for future:

The existing anthropogenic pressure and management applications have been tested from an economic and ecological viewpoint. In the Himalayan region forest resource extraction provides significant subsidiary income to local people after agriculture landuse. The large area of KWLS cannot be properly managed without active participation and involvement of local communities. A possible way to reduce biotic pressure of the Sanctuary requires conservation education through training programmes, capacity building and outreach with respect to sustainable harvesting of natural resources. This emphasizes the greater need of strengthening the community-Sanctuary linkages as biodiversity cannot be conserved and protected merely by setting aside chunks of area as Reserve (Deb and Sundriyal, 2005). Increasing pressure has also led to the invasion of weeds/bushes/thorny bushes that is an example of changes in vegetation dynamics in forest ecosystems (Benjamin et al, 2005). To reduce the pressure of the local people on the forests for their daily fuelwood, fodder and leaf-litter biomass needs plantation of suitable species preferred by local people on wastelands, agro forestry setups and land outside forest boundary set-ups are recommended. Initiatives can also be taken to employ local people into forest protection related jobs as they are more aware with ground realities and loopholes of the protection and patrolling tasks means when and where to focus. This will not infuse a sense of belonging but also increase the level of protection of

the Sanctuary. Since, the area has tremendous scenic beauty, unique landscape with diverse vegetation and rich in valuable biodiversity of plant and animal origin, thus there is a need to identify appropriate site for ecotourism promotion and develop infrastructure without compromising on conservation requirements. It is imperative to set in motion a set of actions that are ecologically, socio-economically and culturally feasible as eco-tourism development has implications for various other sectors of the local economy. Further, there is a need to make policies governing eco-tourism development transparent, so that ground rules for the private sector operations; enterprise development, role of local people and the carrying capacity of the system are all sorted out in consultation with the locals. It is recognized that protection of the critical habitats and long term management of the conservation of biodiversity cannot be achieved without improving the economic conditions of the inhabitants living in and around the Sanctuary and protected areas. Inhabitants being the focal points of the conservation efforts, attempt strives for a balance between conservation development and human needs. Management activities in a Sanctuary need to be based on the scientific, participatory and action research. Indeed adoption of sound policies will require a strong knowledge base, which is presently lacking, more so in this Sanctuary as well as in Himalayan PAs and other biodiversity hotspots in developing countries. Therefore, strong linkages between government, NGO's and other local institutions need to be maintained in order to tackle developmental activities in a consolidated manner. Unless local people are involved in the process of formulation and implementation of conservation policies and programmes the goals of biodiversity conservation and protected area management cannot be achieved. Thus, an integrated approach for ecosystem conservation and sustainable

livelihood of local people under the parameter for environmental conservation is therefore supported by the study.

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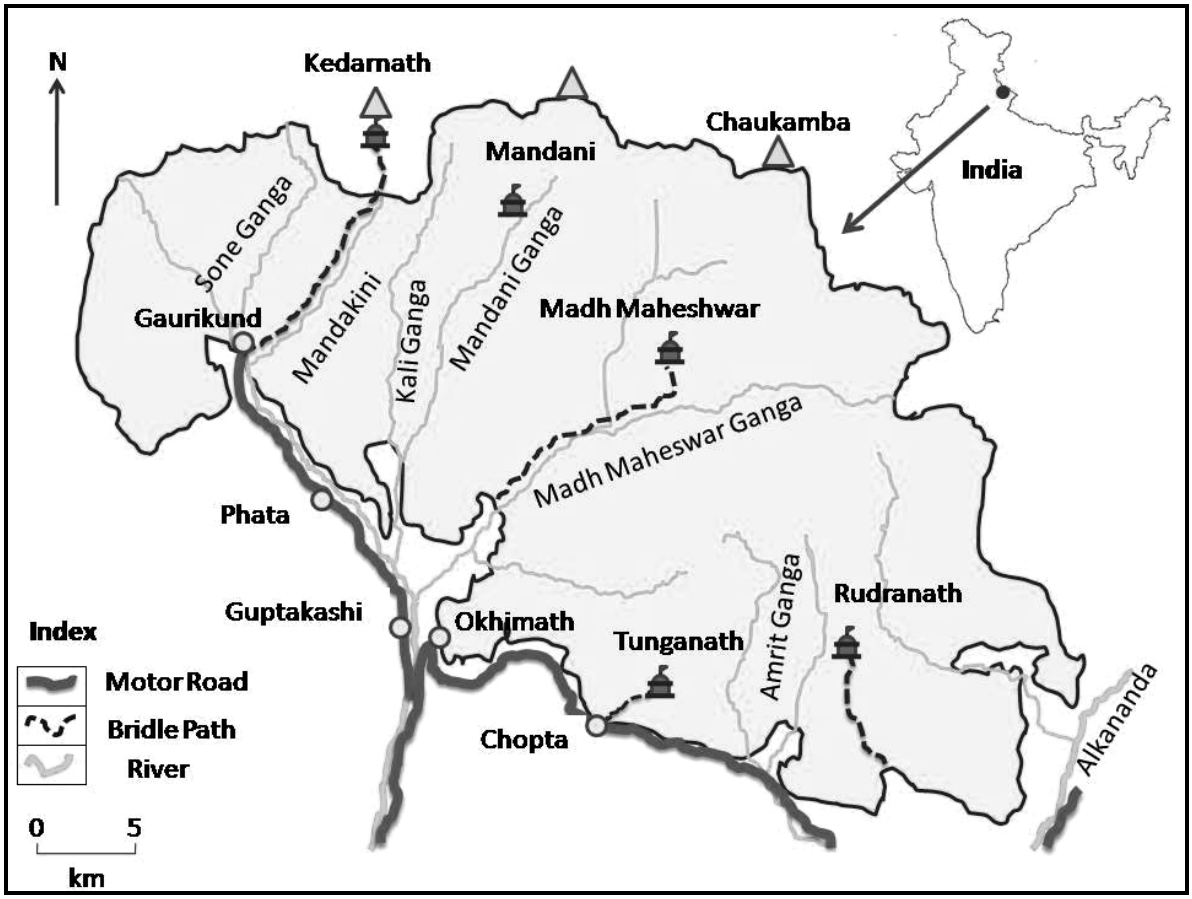


Fig.1. Location map of Kedarnath Wildlife Sanctuary, Uttarakhand, India.

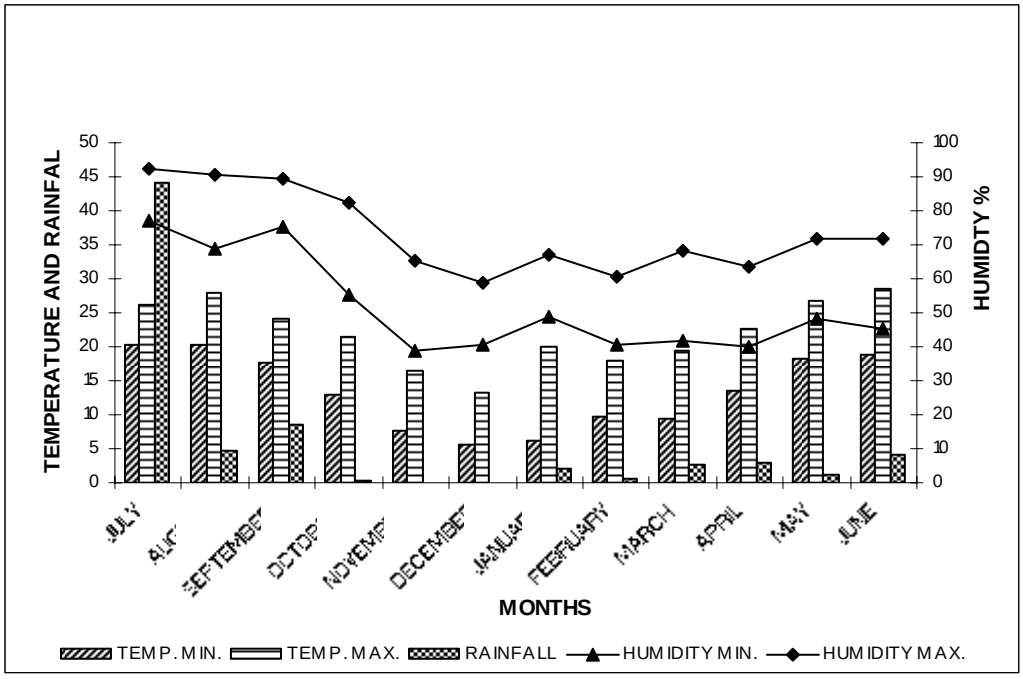
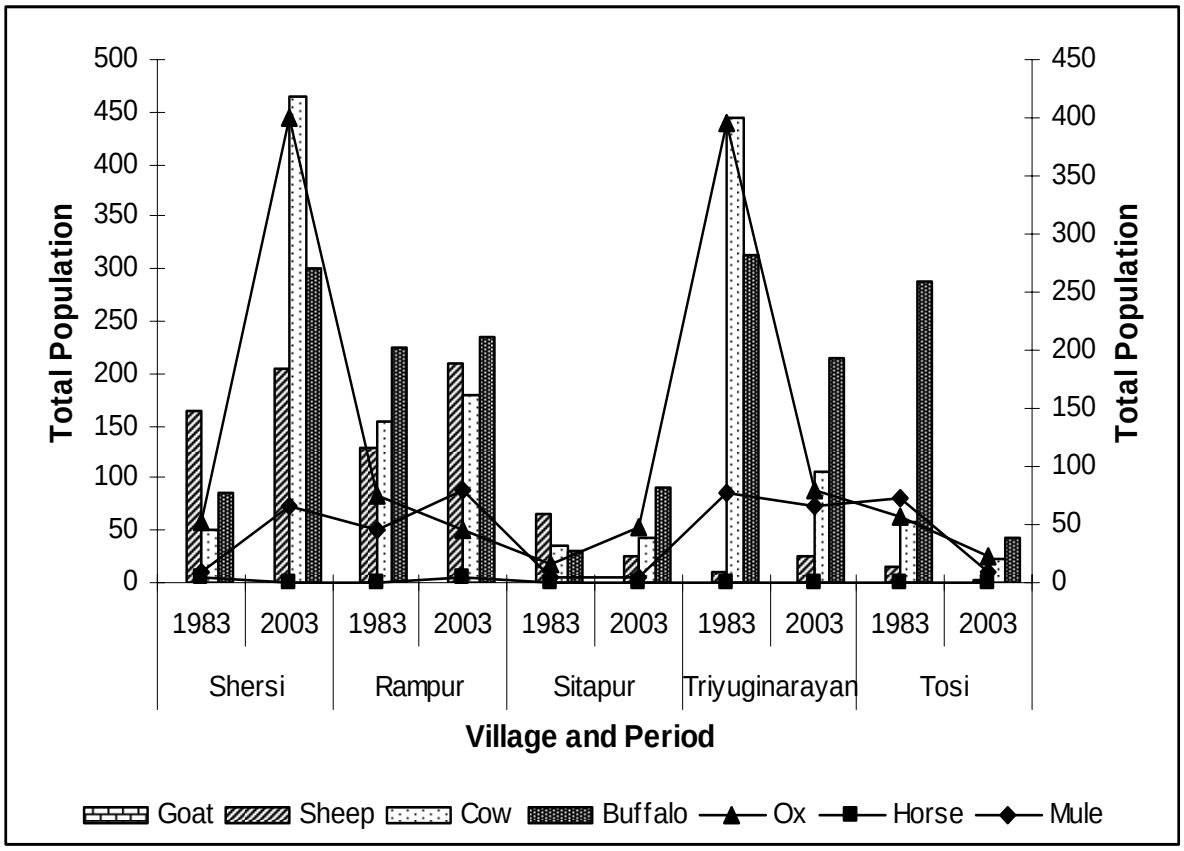


Fig 2: Meteorological data for KWLS for temperature, humidity and rainfall variations (2005-2006)



Fg.3 Changes in livestock population in KWLS fringe area villages

Table 1. Comparative account of important features of Biophysical diversity in Kedarnath Wildlife Sanctuary and selected PAs in IHR

Name of Selected PAs	**Biogeographic Province**	**PA status / Priority**	**Area (km^2) / (altitude m asl)**	**Representative Biomes**	**Representative taxa**	**Remark**
Hemis (Laddakh)	Trans	NP/national	4100/ (3000-6400)	Cold steppe-scrub Cold grassland Glacier/moraines	Snow leopard, wolf, urial, argali, bharal, ibex	Strong hold of Ladakh`s mammals
Great Himalayan (Himachal Pradesh)	North west	NP/national	754/ (1500-6100)	Temperate broadleaved Temperate conifer Subalpine-alpine	Brown bear, bharal, ibex, musk deer, west tragopan	Prolific pheasant population
Nanda Devi (Uttarakhand)	West	NP/national	630/ (3500-7800)	Temperate-conifer Subalpine-alpine	Bharal, musk deer, tahr, serow, snow leopard	Large ungulate populations Representative populations of mountain ungulates and pheasants
Valley of Flower (Uttarakhand)	West	NP/national	87.50/(3250-6750)	Subalpine-alpine	-do-	Large ungulate populations Representative populations of mountain ungulates and pheasants
Kedarnath (Uttarakhand)	West	WLS/national	(957)/ (1300-7000)	Subtropical Pine Temperate broadleaved Temperate conifer Subalpine-alpine	-do-	Large ungulate populations Representative populations of mountain ungulates and pheasants
Khanchendzonga (Sikkim)	Central	NP/national	1784/ (1800-8000)	Subtropical deciduous Temperate broadleaved	Clouded leopard, musk deer, tahr, red panda, takin, wild dog	Impressive wild population of clouded leopard, red panda, musk

				Temperate conifer Subalpine-alpine		deer, snow leopard
Namdapha (Arunachal Pradesh)	East	NP/national	1985/ (300-4500)	Valley evergreen Hill evergreen Moist deciduous Temperate broadleaved Temperate conifer Subalpine-alpine	Leopard, tiger, snow leopard, clouded leopard	Refuge for hoolock gibbon and unique assemblage of carnivores
Dihang-Dibang (Arunachal Pradesh)	East	Biosphere Reserve	5111.5/ (600-5000)	Virgin sub-tropical, grasslands	Takin, serrow, musk deer, snow leopard, goral	Takin, pheasant and very rare and endangered faunal species

NP=National Park, WLS=Wildlife Sanctuary

Table 2. No. of households, total population, average household size, sex ratio and literacy rate of major villages extracting various resources from Kedarnath WLS (According to 2001 census).

Name of the Village	No of Household	Total Population	Household size	Sex Ratio	Literacy Rate
Tausi	23	145	6.30	0.93	54.48
Trijuginarayan	195	1125	5.77	0.99	65.87
Sersi	48	241	5.02	1.11	65.15
Gaurikund	52	260	5.00	0.78	68.85
Kalimath	95	510	5.37	1.03	57.25
Kabiltha	42	273	6.50	1.10	67.77
Khunnu	39	237	6.08	1.15	68.78
Jalmalla	76	479	6.30	0.92	53.86
Jaltalla	40	279	6.98	1.01	55.91
Chamali	60	271	4.52	1.10	49.45
Chilond	49	311	6.35	1.05	67.52
Gair	9	43	4.78	1.53	79.07
Burua	54	294	5.44	1.23	62.59
Basti	13	71	5.46	1.22	56.34
Raulek	226	1015	4.49	1.04	55.86
Paundar	9	29	3.22	0.71	55.17
Ransichak Uniyara	119	580	4.87	1.12	52.07
Dhani	45	258	5.73	0.91	52.71
Tarsali	15	79	5.27	1.32	68.35
Gaundar	42	242	5.76	1.10	65.70
Kotma	128	541	4.23	1.02	75.23
Pali	44	228	5.18	1.40	70.61
Byung	35	197	5.63	1.01	68.53
Kheti Nadla	17	102	6.00	0.96	61.76
Syansu	41	216	5.27	1.12	56.02
Jaggi Bagwan	97	467	4.81	1.08	62.10
Chaumasi	45	267	5.93	1.26	60.30

Table 3. Damage to food crops and fruit trees due to wild life and associated monetary loss in Kedarnath Valley

Crop loss (quantity in kg)	Shersi	Rampur and Sitapur	Triyuginarayan	Tosi	Main agent
Agricultural crops					
Solanum tuberosum (Potato)	858 (8,580)	1,136 (11,360)	2,082 (20,820)	240 (2,400)	Wild Boar and Porcupine
Amaranthus paniculatus (Amaranth)	226 (4,520)	365 (7,300)	468 (9,360)	85 (1,700)	Wild Boar and Monkey
Eleusine coracana (Mandua)	355 (2,485)	460 (3,2200	500 (3,500)	58 (406)	Wild Boar and Monkey
Triticum aestivum (Wheat)	765 (6,120)	884 (7,072)	900 (7,200)	105 (840)	Wild Boar and Monkey
Fruit crops Malta (Citrus spp.)	250 (500)	360 (720)	200 (400)	-	Monkey
Total Loss (Rs/year)	22,205	29,672	41,280	5,346	

Values of monetary loss in Rupees are given in parenthesis

Table.4 Matters relating to death or injury of humans by wild animals year wise and ex-gratia provided for the loss from (1986-2006) to the inhabitants in KWLS fringe area villages

	1986-1990	1991-1995	1996-2000	2001-2006
Major animals that cause harm towards the local inhabitants	Leopard and Beer	Leopard and Beer	Leopard and Beer	Leopard and Beer
Number of human killings and injury as recorded by the Sanctuary authority	31	35	89	66
Amount of Ex-gratia provided by the Sanctuary (Rs.)	83,500	94,000	7,03,000	6,28,000

US$=Indian Rs. 45 approximately

Table. 5 Livestock depredation by leopard and compensation granted for the loss during the 1997-2006 period in KWLS.

Year	Livestock Number	Compensation granted
1997	237	3,30,400
1998	311	4,86,500
1999	124	1,44,450
2000	132	1,61,550
2001	201	2,92,150
2002	73	1,25,350
2003	117	1,84,700
2004	159	2,54,150
2005	219	5,84,750
2006	153	3,46,600

Table 6. Forest resource use, sources, availability status and dependency on KWLS fringe area settlements.

Settlements	Resource Type	Sources	Availability status	Availability distance (km)
Shersi	Fuelwood, Fodder Leaflitter, Timber and NTFPs	BZ*	High	2-3
Rampur	Fuelwood, Fodder Leaflitter, Timber and NTFPs	RF*	Low	4-5
Sitapur	Fuelwood, Fodder Leaflitter, Timber and NTFPs	RF	Low	4-5
Triyuginarayan	Fuelwood, Fodder Leaflitter, Timber and NTFPs	CZ*	Medium-High	2-3
Tosi	Fuelwood, Fodder Leaflitter, Timber and NTFPs	CZ	High	1.5

* BZ=Buffer zone, CZ= Core Zone, RF=Reserve forest, High=>1 to =3 km, Medium=3 to <5 km; Low=>4 km. and Production>Consumption=High, Production=Consumption=Medium and Production<Consumption=Low

Table 7. Indigenous resource use pattern in the fringe area villages

Resource Type	Extraction Process	Species	Frequency	Consumption Calendar	Average
Fuelwood	Felling Lopping Collecting	Q.leucotricophora, Prunus cerasoides, Lyonia ovalifolia, Pyrus pashia, Alnus nepalensis	Once in 2-3 days	Entire year	35.00 Kg
Fodder	Lopping , Chopping	Q.leucotricophora, Myrica esculenta , Debregesia salicifolia	Twice a day	February-May and August-September	2.48±0.29-4.5±0.5 #Bojh/day
NTFP and Wild edibles	Lopping , Chopping, Uprooting	Myrica esculenta, Rhododendron, Diplazium esculentum, Paeonia emoddi	2-3Times a week	March-June	1.5 Kg/HH/day
Leaf Litter	Collecting	Leaves of Alnus Aesculus and Acer caesium	Twice a day	November-April	45 Kg/HH/day

1 Bojh=45 Kg

*Consumption is averaged for all households of all sites

Table 8. Vegetation characteristics of three major forest stands studied on the fringes of Kedarnath Wildlife sanctuary.

Parameter	Protected forest	Community forest	Reserve forest
Administrative institution	Guptkashi Forest Range	Guptkashi Forest Range	Guptkashi Forest Range
Elevation Range (m asl)	1900-2100	1700-2100	2400-2700
Villages	Triyuginarayan, Tosi	Shersi	Rampur, Sitapur
Aspect	East facing	East facing	East facing
Disturbance	Moderate (fuel wood, fodder)	High (all types of resources)	Low/mild (grazing)
Density ha^{-1}			
Trees	880	536.13	1058.94
Sapling	682.65	426.24	509.49
Seedling	336.33	2007.99	1042.29
Lopping	296.37	576.09	36.63
Species Richness	13.25	8.29	14.68
Species Diversity	1.326	1.037	1.631
Concentration of Dominance	0.385	0.523	0.310
Stand Basal Area ha^{-1}	78.59	44.62	84.60
Species with highest basal area ha^{-1}	24.60 Q.leucotricophora	13.26 L.ovalifolia	23.41 Q.floribunda
Dominant Trees	L.ovalifolia, R.arboreum, Q.leucotricophora, N.pallens	L.ovalifolia, Q.leucotricophora, Alnus nepalensis, N.pallens, Betula alnoides	Q.floribunda, C.tamala, Acer caesium, S.paniculata
Trees with no saplings	A.caesium, A.nepalensis, C.tamala, Q.glauca, B.alnoides	–	Abies pindrow, Syzigium cumini
Trees with no seedlings	A.nepalensis, B.alnoides, C.tamala, Q.glauca, Swada macrophylla	–	A.pindrow, S.cumini, J.regia, Aesculus spp., Buxus wallichiana, R.arboreum
Seedlings with no saplings	Prunus cerasoides	P.cerasoides, Ficus neriifolia	Cotoneaster spp., Myrica esculenta
Sapling with no trees	–	Debregeasia salicifolia, Q.glauca, S. paniculata	–
Preferred species (lopping)	L.ovalifolia, Q.leucotricophora R.arboreum, S. paniculata	N.pallens Q.leucotricophora R.arboreum L.ovalifolia	C.tamala, L.ovalifolia
Soil Properties			
Soil Type	Clay	Clay	Clay Loam
pH	6.69±0.18	6.14±0.35	6.03±0.52
% Soil Moisture	46.34±10.18	34.62±7.03	39.27±6.80
Soil water holding capacity (%)	38.07±7.15	41.15±5.07	12.42±1.52
Total Organic Carbon (%)	4.14±0.31	3.71±0.43	2.59±0.44
Total Nitrogen (%)	1.34±0.17	1.09±0.14	1.09±0.11

Table. 9 An Assessment of Biomass extraction by individual HH/annum for their self consumption in studied villages of KWLS

Resource Type	Shersi	Rampur	Sitapur	Triyuginarayan	Tosi
Fuel wood Kg/HH					
Summer+Monsoon	414.62±13.05	442.85±18.38	612.5±75.42	1187.98±76.77	525±0
Winter	288.08±14.91	309.17±12.41	354.37±24.25	450.96±18.76	332.5±52.5
Fodder					
Bojh/HH/Annum#	1332.69±96.10	1301.66±82.10	1072.5±149.54	818.65±97.06	1485±165
Forest floor					
Biomass (Leaf					
Litter)	392.30±31.94	383.33±27.71	450±40.08	334.62±23.98	375±75
Swalti/HH/Season*					
Bamboo					
sticks/HH/annum	511.5±73.03	316.67±14.00	-	345.19±39.35	337.50±37.50
Wild edible fern					
Kg/HH/season	14.59±2.12	12.96±1.42	17.39±5.18	13.18±2.26	20.13±2.86

1 Bojh=45 Kg * 1 Swalti=40 Kg

Table 10. Use and collection of NTFPs including medicinal plants from the forests of KWLS along with their revenue return

Species (local name)	Usage	Degree of use	Status	Peoples' dependency	Market rate Rs/kg
Rhododendron arboreum (Burans)	Edible	Heavy	Abundant	Medium	20.00
Myrica esculenta (Kafal)	Edible	Heavy	Abundant	High	50.00
Zanthoxylum elatum (Timru)	Medicinal/religious	Medium	Scarce	Low	Hidden market
Rubus ellipticus (Hisal)	Edible	Medium	Abundant	Medium	Hidden market
Berginia ciliata (Silphodi)	Medicinal	Light	Scarce	Low	Hidden market
Picrorrhiza kurroroa (Kadvai)	Medicinal	Heavy	Scarce	Low	200.00
Juglans regia (Akhrot)	Edible	Heavy	Common	Medium	50-70/100 piece
Cinnamomum tamala (Dalchini)	Edible	Light	Abundant	Low	18-29
Paeonia emodi (Puyanu)	Edible,	Medium	Abundant	Low	Local collection and consumption
Diplazium esculentum (Lingra)	Medicinal Edible	Heavy	Common	High	25.00
Thmnocalamus faloneri (Ringal)	Crop support	Heavy	Scarce	High	80.00/gathi (with 10 sticks)

Abundant=0.2 km, Common=2-3 km, Scarce= 3-5 km; Low = 2-6 kg, Medium= 10-20 kg, High=>20 kg, Light=1-2 uses, Medium= 2-3 uses, Heavy=>3uses.