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RESEARCH ARTICLE

Significance of provisioning ecosystem services from moist temperate forest ecosystems: lessons from upper Kedarnath valley, Garhwal, India

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Abstract Forests have been very important natural resource for rural subsistence lifestyle providing variety of and provisioning ecosystem services. Study was carried out in six villages of upper Kedarnath valley at an altitudinal gradient of 1400–2800. Paper examines the nature and extent of provisioning services from forests to hill locals living in nearby villages. Frequent field survey of 151 households from five villages in proximity to forest was conducted using semi-structured questionnaires followed by field surveys. Primary data were collected for basic household's attributes, fuelwood, fodder, leaf litter and NTFP collection pattern. Simple descriptive methods were used for data analysis. The result shows that fuelwood contributes more than 95 % of total domestic fuel requirement in the study area with more collection during summers but more consumption during winter months due to extensive drop in day and night temperatures. Fodder collection is a major practice adding a lot to women drudgery, and winter fodder deficit is a major issue that leads to dry fodder collection from remote locations. Similarly the average seasonal collection figures were also high for leaf litter ranging from 120 to 89 kg/household/day. Collection of wild edibles is moderate, while for medicinal plants is low in the study area. Resource availability, collection and consumption depend on the family size, distance from forest area and economic condition of the household. More than 95 % of the household's biomass demands and requirement in the study area are fulfilled completely from forests, while rest are procured from various sources such as agroforests and agriculture.

Keywords Provisioning ecosystem services · Moist temperate forests · Kedarnath valley · Garhwal · Biomass

1 Introduction

The concept of ecosystem services has become an important model for linking the functioning of ecosystems with human well-being (Fisher et al. 2009). But even as demands for ecosystem services are growing, human actions are diminishing the capability of ecosystems to meet these demands. Ecosystem services are the benefits people receive from nature that have immense economic value and play a crucial role in the survival and well-being of human beings. The term 'Ecosystem Services' serves as a catalyst to stress the importance of ecosystems for human well-being. The Millennium Ecosystem Assessment was the first to explicitly underline the linkages between ecosystems and human well-being, coining the term 'ecosystem services' to stress the important benefits that people derive from ecosystems (MEA 2005). This process has conceptualized the connection between the status of ecosystems and various goods and services provided by those ecosystems. The local people are dependent on ecosystems for variety of services such as provisioning in form of food, water, fuelwood. The ecosystems have been largely responsible for regulating floods, purifying water, maintaining the temperature, etc. (Gokhale and Pala 2011). The biological processes such as nutrient cycling, soil formation, etc. are responsible for providing the supporting services to the human society. The human societies are also

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culturally dependent on the ecosystems for spiritual purposes, aesthetic purposes, recreation, etc. Forests provide multiple supporting, provisioning, regulating and cultural services to human well-being. According to studies reviewed by TEEB, the contribution of forests and other ecosystems to the livelihoods and incomes of poor rural livelihoods is significant (MoEFCC & GIZ 2014). Provisioning services are defined as all nutritional, material, and energetic outputs from living systems. They are tangible things that can be exchanged or traded, as well as consumed or used directly by people in manufacturing. Foods and medicines are some of the most ubiquitous provisioning services of natural ecosystems (Haines-Young and Potschin 2012). Given the diversity of ecosystems found in Indian Himalayan Region, the goods and services provided to the surrounding local communities are immense. In developing countries like India, forests are used extensively for grazing, fuelwood collection and numerous other subsistence needs by rural peoples (Dhyani et al. 2011). While the number of studies based on economic valuation of biodiversity and ecosystem services is growing worldwide, there is still a dearth of similar studies in India Himalayan Region (IHR). There are few studies on provisioning service of forest ecosystem (Negi and Semwal 2010; Joshi and Negi 2011; Mahapatra and Tewari 2005; Purushothaman et al. 2000; Narendran et al. 2001; Murthy et al. 2005; Sarmah and Arunachalam 2011). It is already suggested that flexible forest management policies are capable of fostering a balanced distribution of forest products to local forest users in order to fix the unbalanced relationship between farming communities and forest resources (Varughese and Ostrom 2001). Fast changes in large-scale human and biophysical processes—population explosion and migration, over-harvesting and changes in traditional land use—have led to loss of the overall productivity of socio-ecological systems in terms of quality and quantity. Despite the provision of multiple valuable services, the forests in Indian Himalayan Region are threatened. The threats are both local and global in origin and include non-sustainable resource harvesting practices; upcoming mega-hydropower projects; pollution and waste; sand mining; damaging tourism practices; invasive alien species; climate change-related increases in temperature and retreating glaciers due to increasing human pressure on this fragile and sensitive ecosystem. All these have been critically disturbing the balance between the productivity of forest ecosystem, biodiversity conservation and its utilization by the stakeholders for their welfare. There is increasing concern that this dispiritedness might lead to a prompt decline in the provisioning, regulatory, supporting and cultural services of this region and adversely impact the provision of ecosystem services downstream. Several scientific and political forums have reinforced the exclusivity, environmental challenges and political inheritances of the Himalayan region and the need to address the extremely diverse environmental threats faced by the region in policy making (Blaikie and Muldavin 2004; Gautam et al. 2013). Therefore proper policy should be framed, which should integrate the demand from the forest by the stakeholders and biodiversity conservation. Present study is user-inspired and user-useful, which was fulfilled by researchers by responding to stakeholder needs from the outset and collaborates with them for strategy development and implementation. The aim of this case study is to provide an overview of important provisioning ecosystem services from mixed broad-leaved temperate forests of Garhwal in Western Himalayas. Given the limited time and resources, key provisioning services from forests of Uttarakhand were considered for assessment and a range of methods have been used. The ecosystem services that we examine are the provision of bio-resource opportunities and the support for sustenance lifestyle of hill locals. The paper raises and also seeks answer to the question: How can ecosystems be used as sustainable sources of energy and how can biomass be harvested in a way that does not jeopardize the provision of other ecosystem services? Study emphasizes on protection and/or restoration of important forest ecosystems in Himalayas that provide basic provisioning services for local communities and other beneficiaries. In the context of natural resource management and conservation, the objective of mainstreaming of present study is to internalize the goals for safeguarding resources into economic sectors and development models, policies and programs, and therefore into all human behaviour.

2 Study area and climate

Upper Kedarnath valley is one of the bio-diverse areas of Kedarnath Wildife Division, Uttarakhand, situated in Rudraprayag district of the state that includes a large area under protected, reserve and community forest categories (Fig. 1). The major vegetation/forest type is categorized into nineteen broad forest types that are based on Champion and Seth's Classification (Champion and Seth 1968; Roy et al. 2015). Area covers a wide altitudinal range from 1600 to 2800 m.a.s.l. with a varying mean annual temperature range of −2 to 30 °C, and mean annual precipitation during the study period was 1752 mm (Misra 2009). There are six villages located in the upper Kedar valley: Tausi (2800 m.a.s.l.), Triyuginarayan (2600 m.a.s.l.), Kongarh (2200 m.a.s.l.), Nyalsu (2000 m.a.s.l.), Shersi (at 1800 m.a.s.l.) and Maikhanda (at 1400 m.a.s.l.). All villages comprise forests that are protected under different legal categories (Tausi and Triyuginarayan: Kedarnath Wildlife Sanctuary; Kongarh and Maikhanda: reserve/revenue forests; Nyalsu and Shersi: community forests). Dominating tree species in the forests around the villages are Ring-cupped Oak (*Quercus glauca*), White Oak (*Q.*

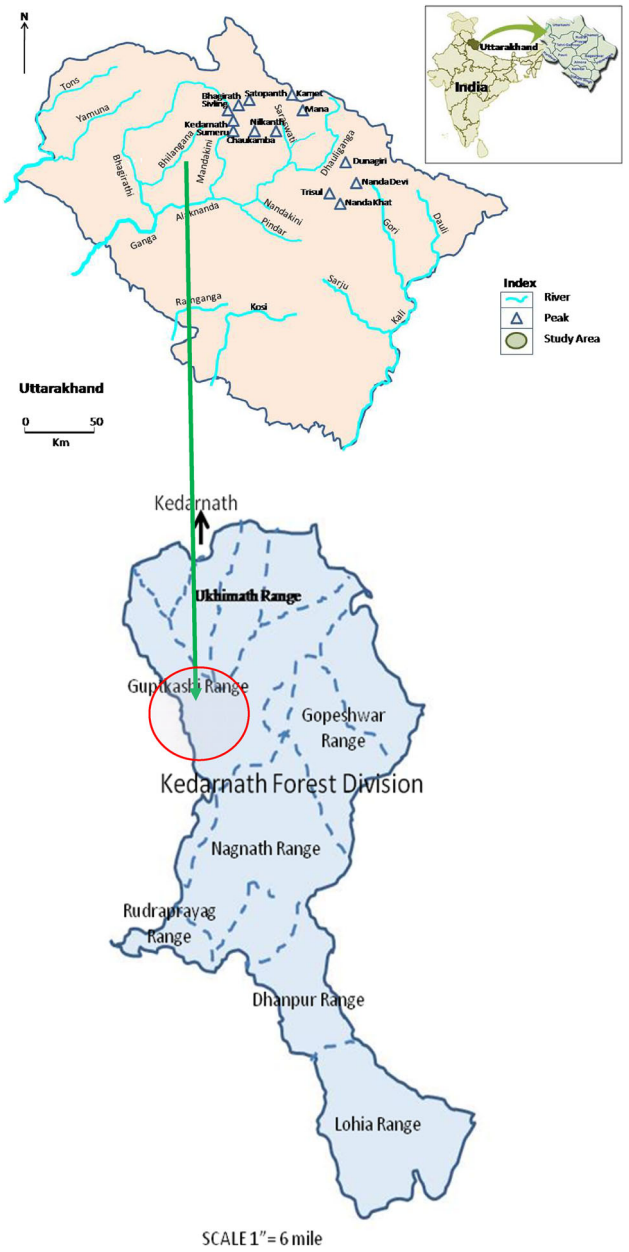

Fig. 1 Location map of the study area in upper Kedarnath valley of Kedarnath Wildlife Division, Uttarakhand, India, and also showing the location of Kedarnath Wildlife Sanctuary on top (*Map not to scale*)

leucotrichophora), Green Oak (*Q. floribunda*), Brown Oak (*Q. semecarpifolia*), West Himalayan Fir (*Abies pindrow*), West Himalayan Spruce (*Picea smithiana*), Himalayan Yew (*Taxas baccata*), Oval-leaved Lyonia (*Lyonia ovalifolia*) and Rhododendron (*Rhododendron arboreum*). The forests of the valley provide refuge to some rare and threatened wildlife, for example the Himalayan musk deer (*Moschus chrysogaster*), Himalayan snow leopard (*Panthera uncia*), Indian leopard (*Panthera pardus fusca*), Himalayan Tahr (*Hemitragus jemlahicus*), blue sheep/Bharal (*Pseudois nayaur*) and Himalayan Monal (*Lophophorus impejanus*) (Misra 2009). Study area is also inhabited by a large number of local transhumants besides tourists and pilgrims during summer as famous Kedarnath shrine is situated in the area. The main pressure on the forests of the area is during summers that involve local graziers, herders and local transhumants and local collection of fuelwood, fodder and leaf litter. Additionally, there is an immigrant Nepalese population of about 5000–8000 individuals that visit the valley for occasional employment opportunities such as household help, porters and daily wagers during the Kedarnath pilgrimage season (from May to October).

3 Methodology

Forests of Garhwal, Uttarakhand, provide valuable provisioning ecosystems services for human well-being that often go unrecorded due to lack of quantified values. Key provisioning ecosystem services (biomass flow/consumable direct use) and prominent resources extracted from the forests included in the survey are: fuelwood, fodder, forest floor leaf litter, wild leafy edibles, fruits, flowers, sticks for crop support (legume and cucurbit crops) and post-harvest storage structures. Physical indicators were obtained to understand the provisioning ecosystem services from forest to nearby villages. Primary data were collected by using different tools such as semi-structured questionnaires followed by group discussions and household interviews as well as guided field walks, and field observations. Local communities interviewed during the study were mostly illiterate. They were composed of farmers, housewives and people belonging to the poorer segments of society who live at the frontline of changes in the environment across the region. Interviews were conducted in the local vernacular languages (Garhwali and Hindi), in which the researchers were conversant. After gathering and organizing information and data related to demography and historical records, a semi-structure questionnaire was designed and survey was conducted. Stratification for the sampling was based on altitude and distance of the villages from the forests. The linkages and dependence of the community with the forests were assessed through field surveys by undertaking formal and informal group discussions. Besides, personal interviews with more than 50 local inhabitants (one adult above 40 years of age from each household sampled) and further data verification by actual field checks. Respondents selected for in-depth interviews were those who have rich experiences in the study area. A total of 15, 50, 15, 50 and 21 households' interviews were completed from Tausi, Triyuginarayan,

Sitapur, Rampur and Shersi villages, respectively. In addition, at least one individual from each household was interviewed, representing a sample size >20 % as recommended by Adhikari et al. (2004). Criterion of study village selection was dependency of village inhabitants on different forest legal categories as per Wildlife Protection Act, 1972 and as they represent an elevation gradient with variations in biomass production and forest extraction practices. Detailed fuelwood, fodder, leaf litter, branches/sticks, medicinal and wild edibles harvesting pattern was studied in selected villages a view to identify the preference towards specific fuelwood, fodder, leaf litter, stick support species in collection. To assess the pattern of availability of different bio-resource species, samples of plant species were identified to species, genera and family level using regional flora (Gaur 1999) and help from Botanical Survey of India, Northern Circle, Dehradun. Preference of specific plant resource for collection was based on informal group discussions followed by interviews with women and by personal observations during field surveys following Martin (Martin 1995). The quantity of biomass (fuelwood, fodder, leaf litter, stick/branches, medicinal and wild edibles) required and daily consumption collected by each sample household were calculated over 24 h by adopting weight survey method (Martin 1995; Mitchell 1979; Maikhuri et al. 1994). The source and supply of fuelwood and fodder was quantified as contribution of agricultural by-products and forests by estimation in the villages and by measuring the daily requirement of fuelwood and ration of food concentrates given to the animals by each household as fodder along with other bio-resources. Simultaneously, observations were also made in each sample household to quantify fuelwood, fodder, leaf litter, sticks/branches and medicinal and wild edibles collection by following them during their regular foray. All the biomass estimated was weighed using a spring balance for winter and summer collection period for fuelwood and fodder and seasonal collection for leaf litter, stick support and medicinal and wild edibles. The annual consumption of fuelwood, fodder, leaf litter and other NTFPs was calculated by summing the requirement in different seasons.

4 Results

4.1 Organization and function of village ecosystem in upper Kedarnath valley

The study area lies in Garhwal part of Uttarakhand in Western Himalaya, and all study area village settlements together have 473 households and 2828 individuals. A general profile of the study area was prepared on the basis of door-to-door survey (Table 1). The average family size was estimated to be 6 individuals/household. Like other high-altitude communities, animal husbandry is practiced by the residents of studied villages. Agriculture and animal husbandry along with tourism-related jobs are the main sources of income in the valley. Livestock is an important source of income as well as wealth in the agriculture-based economy. Average livestock possession is 3–5 animals per household, usually including a cow, 2 bullocks or a buffalo. These livestock besides providing a source of income also have an indispensable impact on livelihood of the marginal people in terms of providing valuable resources and value-added products such as milk, butter, curd, meat, wool and dung. Agriculture is the main occupation of the population and is practiced on terraced slopes under rainfed conditions. Per capita landholding was estimated at 0.59 hectare of rainfed land. Nearly 15–20 crops (e.g. traditional cereals, millets, vegetables, pulses, oil yielding, condiments, spices and medicinal plants) are grown by the farmers; however, only a few are grown on a large scale. Traditionally, farm yard manure (FYM) prepared from cattle dung is used in agriculture without any chemical inputs. Well-maintained orchards of Malta fruit (*Citrus sinensis* variety), elephant ear fig (*Ficus auriculata*) and English walnut (*Juglans regia*) are observed in the villages. Farm area and cropping intensity have changed over the last two decades (Misra et al. 2008) from traditional crops, i.e. finger millet (*Eleusine coracana*) and amaranth (*Amaranthus frumentaceus*) to cash crops such as potato (*Solanum tuberosum*). Cultivation of traditional crops such as Indian barnyard millet (*Echinocloa frumentocea*), soy bean (*Glycine max*), foxtail millet (*Setaria italica*), proso millet (*Panicum miliaceum*) and pearl millet (*Pennisetum typhoides*) has been largely abandoned. The area under potato and kidney bean has also increased in last three decades, adding more pressure on forests. The earlier sustainable harvesting of fodder and other biomass by local communities from the forests is now becoming unsustainable because of increasing human and livestock population and also because of increasing market demands for various forest-based produces (Singh et al. 1998; Misra 2009). This has added more pressure on forests as floor biomass used for farm yard manure and local *ringal* bamboo and branch of some shrubs and trees (*Deutzia staminea* and *Bahunia vahlii*) removal for supporting the legume crop plants. Well-maintained home gardens of Malta fruit (*Citrus spp.*), *Juglans regia* and different types of seasonal vegetables are observed in the villages. Inhabitants have inadequate production of fuelwood and fodder resources and crops on their farmland. Local inhabitants depend on forests for fuel, fodder, timber, NTFPs (Table 2). Traditional arrangements have slowly changed, with increased physical, administrative and economic integration of mountain areas into wider socio-economic systems extending beyond the mountains. The result is

Table 1 General profile of the study area villages in upper Kedar valley, Uttarakhand

Parameter	Villages of the study area				
	Shersi	Rampur	Sitapur	Triyuginarayan	Tosi
Altitude (m)	1800	1900	2000	2500	2750
Distance from motor road (km)	0.5	1	1.5	2	4
Households (no.)	48	170	37	195	23
Population (no.)	241	936	203	1125	145
Landholding (ha.)	85.96	222.6	–	419.426	50.044
Reserve forest (ha.)	33.355	60.642	25.261	66.498	9.331
Community Forest (ha.)	637	–	–	–	–
Livestock (no.)	1478	897	288	518	98

marginalization of both traditional resource use practices and indigenous coping mechanisms. Resource use is more demand-driven in present rather than supply-driven.

4.2 Resource use pattern by communities of upper Kedarnath valley

The dependency of forest dwellers of upper Kedarnath valley on the forests is deeply interwoven with their traditional and indigenous knowledge, which they have acquired through generations from their elders. The indigenous knowledge evolved by these communities is predominantly influenced by the natural forces and so far has been ecologically sustainable. The forests and forest resources are highly recognized for the sustenance they offer to large number of rural households dwelling in close proximity of forests in Garhwal Himalaya. Temperate forests (moist or dry) have played vital subsistence roles to people of upper Kedar valley. Forests have always been valued by locals of Garhwal for their huge ecological, economic as well as aesthetic potential. Communities use a large number of plants for their diverse needs that grow abundantly in the forest areas near their villages. Such plants include timber yielding; oil yielding; fodder yielding; cattle bedding; leaf litter yielding; crop support for various agriculture crops; post-harvest storage; medicinal; spices condiments; and other wild edibles. The dependency of rural people on forest resources in the study villages ranges from fuelwood for domestic energy requirements to fodder for animals, timber for house construction and agricultural implements and a large number of NTFPs for different uses (Fig. 2). We observed variation in resource collection dependent on the socio-economic environment of the local people and also on the availability of desired resources in their approachable distances. The resource extraction from forests in different villages is varied and is primarily dependent on the presence of preferred resources and distance they travelled to extract the resource (Table 3). Resource flow for the entire year shows variation in collection. As for fuelwood and fodder, the extraction is throughout the year, whereas for *ringal* bamboo and leaf litter as major forest resource is seasonal. House structures in the villages of the study area are semi-wooden and *Alnus nepalensis*, *Prunus cerasoides*, *Quercus leucotrichophora*, *Abies pindrow*, etc. are most preferred timber wood. However, the collection of timber is very rare and happens once in many years with frequency of 15–20 years by individual household.

Table 2 Indigenous resource use pattern by locals in the villages of the study area

Resource type	Extraction process	Species	Frequency	Consumption calendar	Average
Fuelwood	Felling lopping collecting	*Q. leucotrichophora, Prunus cerasoides, Lyonia ovalifolia, Pyrus pashia, Alnus nepalensis*	Once in 2–3 days	Entire year	35.00 kg/2–3 day
Fodder	Lopping, chopping	*Q. leucotrichophora, Myrica esculenta, Debregeasia salicifolia*	Twice a day	February–May and August–September	86.8 ± 10.5–157.5 ± 17.5 kg/day
NTFP and wild edibles	Lopping, chopping, uprooting	*Myrica esculenta, Rhododendron, Diplazium esculentum, Paeonia emoddi*	2–3 Times a week	March–June	1.5 kg/household/week
Leaf litter	Collecting	Leaves of *Alnus Aesculus and Acer caesium*	Twice a day	November–April	45 kg/household/day

Consumption is averaged for all households of all sites

Fig. 2 Prominent resources extracted by local people in the study area **a** fodder, **b** timber, **c** forest floor leaf Litter, **d** fuelwood, **e** storage of winter fodder and **f** legume crop support by *ringal* bamboo

4.3 Forest as a source of fuelwood

Fuelwood is the major source of household's energy for the rural population of India. It is difficult to be precise about demand for an item that is mostly collected for subsistence and where substitution occurs. Where fuelwood is easily accessible and the opportunity cost of rural labour is low, fuelwood substitutes for other fuels, leading to higher estimates of needs. Most preferred fuelwood species of the study area are *Quercus leucotrichophora*, *Quercus semecarpifolia*, *Lyonia ovalifolia*, *Pyrus pashia*, *Prunus cerasoides*, *Alnus nepalensis Symplococs paniculata*, *Rhododendron arboreum*, *Aesculus indica*, *Quercus glauca*, and shrubs *Cotoneaster affinis*, *Berberis*, etc. Besides, local *Ringal* bamboo *Chimnobambusa falcata*, *Thamnocalamus spathiflorus*, *Arundinaria* species are also used as minor fuel on availability of other major fuelwood source. Main collection of wood for firewood/fuelwood purposes is of dry and fallen branches on the forest floor because it burns finely emitting less smoke. Fuelwood collection (Kg/household) was observed to be varied in summer–monsoon (S + M) (April–October) with winter months (W) (November–March). Collection was observed to be more during S + M months with less consumption, whereas during winter months less collection was observed during our study. Consumption was observed to be more during winter

Table 3 Forest resource use, sources, availability status and dependency on forests of the study area

Settlements	Resource type	Sources	Resource status	Availability distance from village (km)
Shersi	Fuelwood, fodder leaf litter, timber and NTFPs	CF[a]	High	2–3
Rampur	Fuelwood, fodder leaf litter, timber and NTFPs	RF[a]	Low	4–5
Sitapur	Fuelwood, fodder leaf litter, timber and NTFPs	RF	Low	4–5
Triyuginarayan	Fuelwood, fodder leaf litter, timber and NTFPs	PF[a]	Medium–High	2–3
Tosi	Fuelwood, fodder leaf litter, timber and NTFPs	PF	High	1.5

[a] *CF* community forest, *PF* protected forest, *RF* reserve forest, High $\geq$ 1 to = 3 km, Medium = 3 to < 5 km, Low $\geq$ 4 km. and Production > Consumption = High, Production = Consumption = Medium and Production < Consumption = Low

months (because of snowfall and extremely cold weather conditions) (Fig. 3). An average family consumes at least 6–10 kg of fire wood per day during summer, which goes as high as 15–20 kg per day during the winter. Detailed consumption pattern data for fuelwood per household per year are not presented in this paper. Collection in S + M varies from 1187.98 to 414.62 kg/household/year, while for winter it varies from 450.96 to 288.08 kg/household/year. Observed fuelwood collection was observed maximum for Triyuginarayan and minimum for Shersi village during summers and monsoon (Fig. 3). Collection in winter was again observed highest for village Triyuginarayan and lowest for village Shersi (Fig. 3). Recorded results also reflect the higher collection for high-altitude villages and comparatively less for lower altitude.

4.4 Forest as a source of fodder

Fodder obtained from arable land is not sufficient to maintain the livestock in sound health. Therefore, the inhabitants largely depend upon the forest-based fodder resource. A large variety of tree species, forest floor phyto-mass and agricultural by-products are used as animal fodder in the study area. A total of about 48 prominent fodder species (including trees, shrubs and herbs) were observed based on the field investigation. Most preferred tree fodder species are *Quercus leucotrichophora*, *Quercus semecarpifolia*, *Quercus floribunda*, *Quercus glauca*, *Acer caesium*, *Aesculus indica*, *Ficus nemoralis*, *Ficus palmata*, *Debregeasia salicifolia*, *Prunus cerasoides*, *Carpinus viminea*, *Vibrnum mullaha*, etc. *Besides*, *local Ringal bamboo species* viz. *Arundinaria falcate*, *Thamnocalamus falconeri* and *Thamnocalamus spathiflora* species are also used as minor fodder. There are many grasses in forests, pastures and agriculture sector that are preferred as fodder. The scarcity of fodder in hills is felt not only because of declining area under forests but also due to rapidly growing population. The collection of fodder was observed varying from village to village, and its quantity varied from village to village (Table 4). Fodder collection was directly proportional to livestock/household, distance travelled for collection as well as how many members of a single household were involved in collection. Fodder collection was recorded maximum based on both demand and supply for Shersi village, i.e. 50884.62 $\pm$ 3669.45 kg/household/annum and 46644.23 $\pm$ 3363.66 kg/household/annum, respectively. Minimum, i.e. 31257.69 $\pm$ 3706.28 kg/household/annum demand and 28652.88 $\pm$ 3397.42 kg/household/annum supply, respectively, was

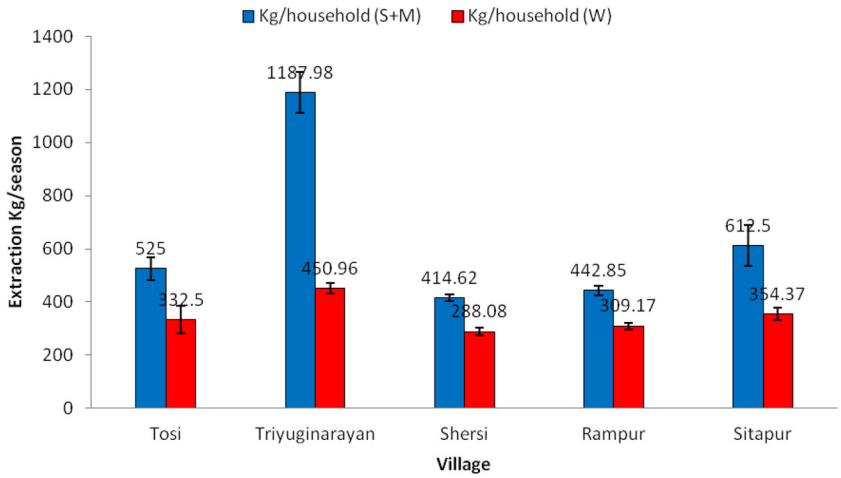

Fig. 3 Overview of fuelwood collection by local households of the study area during summer + monsoon (S + M) (April–October) and winter (W) months (November–March) per household/year

observed for Triyuginarayan village situated at higher altitude than Triyuginarayan (Table 4). Dense, diverse oak and broad-leafed forests are continually deprived of their fodder species as these are progressively cut back to the trunk. When the leaf area becomes small, the tree dies and is cut for fuelwood. Partial as well as complete lopping is used to harvest from forests and non-forest resources. Collection of fodder during winter months (November–February) was found comparatively lower to green fodder collection months (March–October). This was because of unavailability of fodder in their village vicinity as well in forests because of harsh winters, snow fall and leaf fall from trees. During lean dry period of winter, unavailability of nutritious green fodder leads to feeding of livestock on low-quality straw, crop residue and dry grasses that also impacts the quality and quantity of milk yield.

4.5 Forest as a source of leaf litter or forest floor biomass for organic supplement to forest-dependent local agriculture

Application of organic manures (bio-fertilizers) is the only option to improve the soil organic carbon for sustain of soil quality and future agriculture productivity. Leaf litters of different plants species play an important role in the preparation of conventional bio-fertilizers. Leaf litter collected from forest floor lasts from November (last) to March/April for about 6 months initially as cattle bedding and later to use it for preparing farm yard manure (FYM) for providing organic supplement to crops in local forest-dependent agriculture. After 2 or 3 days leaf litter being used as cattle bedding it is mixed with cow dung and removed from the cow sheds to be stored in protected space for 2–5 months, so that the materials are decomposed completely before using it as manure. Preferred tree leaves used for cattle bedding and later for preparing FYM are *Juglans regia*, *Aesculus indica*, *Acer caesium*, *Fraxinus micarantha*, *Alnus nepalensis*, *Pyrus pashia*, *Symplocos paniculata*, *Myrica esculenta*, etc. Leaves of these tree species are considered best for preparing FYM based on their fast decomposition. Most of the dry biomass or leaf litter is removed from forest floor according to preferred resources available, and subsequently all forest floor leaf litter from nearby approachable forest fringes is removed. Initially *Acer caesium* leaves are removed followed by *Aesculus indica*, *Alnus nepalensis*, etc. But the leaf litters of these species were not available through the year, due to their deciduous and early decomposing nature. *Quercus leucotrichophora*, *Rhododendron arboreum* and *Lyonia ovalifolia* were highly used as leaf litter to prepare conventional manure (bio-fertilizers) in oak zone, due to their local abundance and availability throughout the year. Agriculture practices in the study area are traditional, organic, forest resource-dependent and cropping patterns, and crops are with very low external support. Forest leaf litter or floor biomass removal was observed and recorded to be maximum by Sitapur village daily (120 ± 10.69 kg/day/household); monthly (3600 ± 320.71 kg/month/household); and annual/seasonal (18,000 ± 1603.57 kg/annum/household), whereas lowest was reported from Triyuginarayan village daily (89.23 ± 6.39 kg/day/household); monthly (2676.92 ± 191.86 kg/month/household); and annual/seasonal 13384.62 ± 969.29 (Kg/annum/household) (Table 5).

4.6 Forest as a source of NTFPs

Key provisioning ecosystem services and prominent resources extracted from the forests in the survey were, fuelwood, fodder, leaf litter, NTFPs that include wild leafy edible (*Diplazium esculentum*); fruit (*Myrica esculenta*); flowers (*Rhododendron arboreum*); medicinal plants (*Picrorrhiza species*); sticks for crop support (legume and cucurbit crops) and making baskets as well as handicrafts (*Chimnobambusa falcata*, *Thamnocalamus spathiflorus*, *Arundinaria* species). Study area is known to be accretion of in numerous wildly growing plants providing immense support towards dietary support to local inhabitants. Wild plants are gathered in the form of fruits, shoot, leaves, twigs, flowers, roots, tubers stems, etc., and these plants

Table 4 Evaluation of fodder collected for feeding livestock holdings/annum

Village	Kg/household/day	Fodder demand Kg/household/annum	Fodder supply Kg/household/annum	Fodder deficit Kg/household/annum
Tosi	112.5 ± 12.5	56,700 ± 6300	51,975 ± 5775	4725 ± 525
Triyuginarayan	86.82 ± 10.30	31257.69 ± 3706.28	28652.88 ± 3397.42	2604.81 ± 308.86
Shersi	141.35 ± 10.19	50884.62 ± 3669.45	46644.23 ± 3363.66	4240.39 ± 305.79
Rampur	138.06 ± 8.71	49,700 ± 3135.10	45558.33 ± 3694.9	4141.67 ± 559.8
Sitapur	113.75 ± 15.86	40,950 ± 5709.86	37537.5 ± 5234.04	3412.5 ± 475.82

Demand of fodder @12 months, Supply of fodder @11 months (because of illness, heavy showers and other purposes for some days every year they are unable to collect resources and we took about 30 such days throughout the year)

still share a good proportion of tribal dishes world over. Wild edibles are frequently consumed throughout the various months and seasons of the year and gathered by the local inhabitants from high altitudinal zones of the study area. In addition to fresh consumption in season, many are processed, fermented for storage and used off-seasonally too. 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 a few medicinal and aromatic plants in the area that are known to be frequently collected by locals. *Morchella esculenta* locally called as *Gucchi* collection is also recorded in the area. Local *Ringal bamboo* is frequently used to support cucurbit and legume crops mostly climber crops and other desired timber and fodder yielding species besides are used for various purposes. Extraction of bamboo sticks was observed and reported to be varied from 316. 67 ± 14.00 to 511.54 ± 73.03 sticks/household/annum based on quantity of *Rajma* seeds they sow per year. Maximum collection of local bamboo sticks for crop support was recorded for Shersi village (511.54 ± 73.03 sticks/household/annum), whereas 316.67 ± 14.00 sticks/household/annum were recorded as minimum extraction from Rampur village (Table 6). Most of the wild edibles are extracted for their own (local) consumption and in a very less quantity for local marketing based on their status in natural nearby forests; utilization by locals and people's dependency for utilizing the resource as alternative livelihood option (Table 7).

5 Discussion

Provisioning services or the supply of goods of direct benefit to people is often with a clear monetary value, such as timber, medicinal plants, fuelwood, fodder and food. Human societies are highly dependent on the supply of provisioning services (food security, environmental and ecological security and sustainability) provided by natural ecosystems in their vicinity. Present study also provides evidences about dependence of direct contribution of natural resources to communities. This dependence is based on the availability, accessibility and economic and physical condition of the user. The dependence on resources for direct profits relates to communities and individuals whose social order, livelihood and stability are a direct function of their resource production and localized economy. The Himalayas are among the most significant eco-regions of the India and world at large, sustaining a large part of humanity through the ecosystem services. Ecosystem services of Himalayas are provided through climatic and hydrological modulation; modulation, nutrient cycling and provisioning biodiversity, thus supporting millions of agricultural and forest-dependent livelihoods. The ecosystem services hinge upon the varied and extensive forest cover across this region, that is also under increasing threat of degradation from over-exploitation, infrastructure development and climate-led variabilities and vulnerabilities. The flows of provisioning services do not accurately reflect their condition, since a given flow may or may not be sustainable over the long-term continuous extraction of resources. Transformation in the traditional life style due to changing socio-economic conditions is leading to transition in the resource use in the study area. In the present study, it has been observed that one of the reasons for forest degradation is increase in population, expansion of agriculture and increase in livestock along with horse and mule population under the influence of market economy coupled with the transformed traditional practices. Annually 24,000 m^2 of areas under forests and scrub are converted to agricultural fields (Awasthi et al. 2003). Traditionally, local inhabitants in the study area have depended on the forest resources for their diverse needs, which are met by community forests, reserve forests and also from protected forest fringes that are designated area to meet people's demand. Unfortunately, the crop production is hardly sufficient to sustain a family throughout the year, and therefore to maintain the livelihood local people depended on natural resources to a large extent for various needs. Local people in all villages of the study area require bamboos for their various basic needs, it has always played an important role in the socio-economy of tribal and rural people (Ram and Tandon 1997), and over thousands of economic applications have been identified for bamboo around the world (Sastry 2001). Besides, timber, local *ringal* bamboo

Table 5 Forest floor biomass/leaf litter collected used as animal bedding and for preparing FYM (from November to April)

Village	Kg/day/household	Kg/month/household	Kg/annum/household
Tosi	100 ± 20	3000 ± 600	15,000 ± 3000
Triyuginarayan	89.23 ± 6.39	2676.92 ± 191.86	13384.62 ± 969.29
Shersi	104.62 ± 8.52	3138.46 ± 255.59	15692.31 ± 1277.94
Rampur	102.22 ± 7.39	3066.67 ± 221.70	15333.33 ± 1108.49
Sitapur	120 ± 10.69	3600 ± 320.71	18,000 ± 1603.57

Season for forest floor biomass collection or removal lasts for about 5 months, i.e. (November–March)

Table 6 Evaluation of sticks of trees to support the crop during the season of Rajma (*Phaseolus vulgaris*) and cucurbit crops (May–June last)

Village	Total clump*/household/annum	Total sticks/household/annum
Tosi	13.50 ± 1.50	337.50 ± 37.50
Triyuginarayan	13.81 ± 1.57	345.19 ± 39.35
Shersi	20.46 ± 2.92	511.54 ± 73.03
Rampur	12.67 ± 0.56	316.67 ± 14.00
Sitapur	–	–

Clump* = Bundle of approximately 25 small-sized sticks

Table 7 Use and collection of NTFPs including medicinal plants from the forests of the study area

Species (local name)	Usage	Degree of use	Status	Peoples' dependency
Rhododendron arboreum (Burans)	Edible	Heavy	Abundant	Medium
Myrica esculenta (Kafal)	Edible	Heavy	Abundant	High
Zanthoxylum armatum (Timru)	Medicinal/religious	Medium	Scarce	Low
Rubus ellipticus (Hisal)	Edible	Medium	Abundant	Medium
Berginia ciliata (Silphodi)	Medicinal	Light	Scarce	Low
Picrorrhiza kurrooa (Kadvai)	Medicinal	Heavy	Scarce	Low
Juglans regia (Akhrot)	Edible	Heavy	Common	Medium
Cinnamomum tamala (Dalchini)	Edible	Light	Abundant	Low
Paeonia emodi (Puyanu)	Edible	Medium	Abundant	Low
Diplazium esculentum (Lingra)	Medicinal Edible	Heavy	Common	High
Thmnocalamus faloneri (*Ringal*)	Crop support	Heavy	Scarce	High

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 ≥ 3 uses

and preferred fuelwood species were also harvested in large quantities and stored for winter season. House structures are semi-wooden, and *Alnus nepalensis*, *Prunus cerasoides*, *Quercus leucotrichophora*, *Abies pindrow*, etc. are most preferred timber species for the wall material though they are continuously declining from the forests of the area and are present in low densities with poor regeneration (Misra 2009). The higher consumption was largely due to easy accessibility for fuelwood along with lack of other energy sources like LPG and improved *chullahs*. Interviews with the residents of the area revealed that previously the adjacent forest areas had fairly good densities of important timber and fuelwood species. A large quantum of fuelwood is required for various purposes in these villages as it is the cheapest source of energy available in valley. Though LPG is also available in some houses but high costs and infrequent availability, it is more of a status symbol than utility. It was also observed that local people choose the species based on the availability not on the fuelwood property or timber quality. The diversity of use of fuel species depends on the wood quantity, accessibility, availability and also human population of surrounding villages (Sundriyal and Sharma 1996). The tribal and rural dependency of forests for fuelwood has been considered responsible for serious deforestation in many parts of India including Garhwal (Ramakrishanan 1987). In one of the very earlier studies, per capita annual consumption of dry wood in various parts of Himalaya has been reported to be much higher ranging between 500 and 1200 kg/year (Singh 1989). There was a spatio-temporal variation in fuelwood and fodder extraction. The present study showed that the fuelwood consumption among the communities ranged from 6 to 10 kg/day in summer months and 15–20 kg/day during the winters, which was higher than the values reported in Western Himalaya (Nautiyal 2013; Singh et al. 2010), Central India (Sharma et al. 2014); SriLanka (Reddy 1981) and other South-East Asian countries (Donovan 1981; Wijesinghe 1984). The villagers use fuelwood for cooking, preparation of the cattle feed, boiling of water, etc., and the consumption doubles in winter than in summer. Due to influence of market economy, livestock composition has also altered. Earlier sheeps and goats composed more than 50 % of the livestock, but now more than 60 % of the livestock is composed of bovines and mules in the valley. The reason for this is the need of organic manure for

agriculture fields and transportation of products to road head and also their requirement for tourists during peak tourist season. Increased cattle to land ratio (8:1) has not only increased pressure on the available grazing grounds but also increased the demands of lopped fodder from the forests (Dhyani et al. 2011). Besides, community demands livestock population along with the increased horse and mule population in the area because of tourism-related activities form another major potential threat for future. Though this pressure is not that intense at present, increased resource dependency on forests can affect the status of most preferred species and forest as well in near future. Livestock and agriculture are completely dependent on the forest products. Local communities who live in the close vicinity of forests face both direct (depletion of ecosystem goods) and indirect (climate change) impacts of degradation of forest resources. Considering the high extraction quantities per household per village, the rise in human and livestock population patterns of fuelwood and fodder consumption would also become unsustainable in near future. At permanent village where most of the livestock remained from October to April, they were strictly stall fed during the periods of snowfall; otherwise, stall feeding was accompanied with grazing. Fodder demands were basically fulfilled through leaf fodder, agricultural by-products (of *Fagopyrum esculentum*, *Eleusine coracana*, wheat, etc.) and grass fodder (green and dried). On the other hand, a change in cropping pattern (Nautiyal and Kaechele 2007) from traditional millets and cereals to potato, French bean and hybrid variety of wheat has already reduced the availability of agricultural by-products as fodder. Therefore, most of the requirements of fodder is now fulfilled from surrounding forests. State of Uttarakhand, especially higher reaches of Garhwal, is soon to become fully organic. Organic farming has been considered beneficial towards the sustaining their livelihood as well as conservation of biological diversity and cure of health. Traditional crops grown using FYM are receiving comparatively higher and better prices than the other crops grown using chemical fertilizers. But this growing concern might add the woes of agriculture extension inside forests along with large amount of forest floor leaf litter removal. Removal of leaf litter from forests is frequent during winters (due to easy availability of dry leaves on forest floor). During the process of removal small tree seeds are also removed disturbing the regeneration processes in forests. Among NTFPs, local bamboo and other species are now very thinly present in the nearby forests, and hence, ban is also imposed by forest department for extraction of *ringal* bamboo species in large quantities. There is also an increasing scarcity of various non-timber species such as wild edibles and medicinal plants because of harvesting of these wild edibles by complete lopping of branches, e.g. harvesting of *Rhododendron arboreum* flowers during winters for value-added products and *Myrica esculenta* fruits during summers. With the trends of unsustainable resource harvesting and utilization of provisioning ecosystem services present in the area, with in next few decades the forest in the vicinity of permanent villages and temporary huts would be used up completely. The unavailability of preferred species near settlements would force people to disperse to relatively undisturbed mid-elevation forests. Thus, increased and unsustainable land-use practices and human activities will likely shrink relatively undisturbed mid-elevation forest. Interestingly, all studied villages and forest patches based on their legal status as per Wildlife Protection Act, 1972 reflect that in the course of providing provisioning ecosystem services and biomass all sites were exposed to equal distribution and it does not mattered to locals if the forest was protected by forest department or by village community. The study reflects quantities of provisioning services provided by the forest ecosystems services that have been central to economic and financial decisions and transactions. Most of these the service, which cannot be translated into direct tradeable goods like production of FYM using forest floor leaf litter and crop support by using thin branches of trees, shrubs and *ringal* bamboo have largely been ignored by the policy planers, till recently. To understand the actual value of services provided by natural ecosystems and to assess their linkages with human well-being, it is important to have information about the quantity, quality and economic worth of ecosystem services. The National Biodiversity Action Plan 2008 and National Mission for Sustaining Himalayan Ecosystems 2009 have now provided measures for reducing the environmental impacts of production and use of ecosystem goods and services. These legislative measures emphasize the need for incorporating the costs of depletion of natural resources into the decisions of economic actors to reverse the tendency to treat these resources as "free goods" and to pass the costs of degradation, thus integrating environmental concerns in economic and social development.

6 Conclusion

Human well-being can be enhanced through sustainable human interaction with environment and its products with the support of appropriate management instruments, institutions and improved technology. Creation of these through participation and transparency may contribute to people's freedoms and choices and to increased economic, social and ecological security. For poor people, the greatest gains in well-being will occur through more equitable and secure access to provisioning ecosystem services. In order to

address the issue of declining ecosystem services and goods within the mountain landscape, there is an urgent need to promote an integrated conservation approach to ecosystem services, including assessment, stakeholders' engagement and payments for ecosystem services aimed at enhancing the flow of benefits to the surrounding communities. The findings show that ecosystem goods such as water and non-timber forest products such as fuelwood, fuelwood, leaf litter are already stressed by over-exploitation. In response to the identified stressors, it could be suggested for sustainable land-use practices and exploring market-based mechanisms to incentivize conservation initiatives. For safeguarding ecosystem services, it is important to empower stakeholders to implement effective on-the-ground management that will achieve resilience of the corresponding social-ecological systems. The prerequisites in these aspects are democratic and accountable governance, awareness and knowledge, and organizational and institutional capacity. The academician and policy planners should put a positively thinking in this direction as provisioning ecosystem services are directly linked to well-being of the people, and considering the poverty trap in IHR, there is no short-term alternative and solution to it.

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