Valuing the Services Provided by Forests and Agro-Ecosystems in the Central Himalaya

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Abstract

Oak and pine are the two dominant forest types in the Central Himalayan region. Local people traditionally utilise provisioning services of these forests for maintaining agroecosystems, and also make invaluable contributions to the conservation of forest resources and maintaining high agrobiodiversity. In community forestry programmes, when climatic and edaphic conditions are favourable, local people give preference to the conservation of oak forest over pine forest, as they perceive that the former provides qualitatively better provisioning (fodder, fuel wood, leaf litter, fresh water etc) as well as regulating and supporting services. As such, determining the use value of services provided by different forest types may help decision-makers prioritise forest conservation programmes in the region and design appropriate incentive based mechanisms, addressing opportunity costs and encouraging sustainable resource use.

Introduction

Environmental services (ES) are defined as a wide range of conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life (Daily 1997). According to Costanza et. al. (1997) these ecosystem processes are worth many trillions of dollars annually, yet most of these benefits carry no price tag that could help alert societies to changes in their supply or deterioration of the ecosystems that generate them. Hence quantification and monitoring the flows of ES for their valuation is important. However, the scale at which services can and should be reported is entangled in complex scientific, policy and institutional challenges, especially as the benefits provided by a given ecosystem often fall unequally across different groups. Stating that natural ecosystems and the services they provide are valuable immediately leads to the questions: how valuable, and to

whom? Current conservation paradigms frequently emphasise conservation of wild biodiversity and ignore species extinction from agro-ecosystems, which may jeopardise household food and nutritional security in the long-term and create higher opportunity costs for local households to implement sustainable agri-environmental measures (Perrings et. al. 2006).

At the G.B. Pant Institute of Himalayan Environment and Development (GBPIHED), attempts are ongoing through an in-house project to address the quantification and valuation of ES provided by major forest ecosystems in the region, including agroforestry. A number of villages are being studied, located at different altitudes and dependent either on oak (*Quercus spp*) and pine (*Pinus roxburghii*) forests for various ES. This research is intended to inform the design of regeneration / afforestation programmes to enhance specified ES, whilst ensuring the productivity of traditional agroecosystems. Such studies can also inform decision making in land use planning and developing suitable conservation strategies.

Methodology

In this article previous studies undertaken by the authors (Singh et. al. 1992) are used and referenced. To quantify various forest environmental services (e.g., fuelwood, fodder and manuring leaves) a door-to-door visit was made using a structured questionnaire, with over 60% households in the two villages sampled. Village Naugaon, 1120 m above sea level, is mostly dependent on a pine forest and village Nanpapo, 1420 m above sea level, is dependent mostly on oak; both represent typical farming systems in Uttarakhand state, India, in the Central Himalaya and are of similar size and population.

Environmental services of Central Himalayan forests

In the Central Himalaya, forest ecosystems are quite distinct owing to varied altitude, geology, topography and climate. The forests of this region range from sal (*Shorea robusta*) - mixed broadleaf deciduous forests in the foothills - to evergreen conifer broad-leaved forests at high altitudes. In the most populated zone of this region (1000 – 2000m altitude), oak and pine are the dominant species. Of the total forest area under the control of the Uttarakhand State Forest Department, the areas under pine and oak forests are 3993.3 and 3000.7 km^2, respectively. With 40% of the area under good forest cover, forests of Uttarakhand are playing an important role in sequestering a huge amount of carbon (C). The natural forests of the region contain 496 million tonnes of C in biomass and soil components (Singh 2007).

The specific ES offered by the two forest types are quite different. The oak forests are valued by the local people as they serve most effectively in terms of delivering goods such as quality fuel wood, year-round green fodder, nutrient-rich manuring leaves (the leaf litter contains 1.72% nitrogen (N) as compared to only 1.02% N in pine leaf litter), and a variety of minor forest products including medicinal plants. The oak forests are further known for retention of rainwater for a longer period and give rise to springs, utilised for drinking water and other household consumption by the local people. Among the important goods provided by the pine forests are timber and resin; the bark is used as fuel by blacksmiths. Singh and Singh (1992) computed that the C stored in oak forests (i.e. 368.3 t/ha) is much higher than that of the pine forests (174.6 t/ha) in this region, and the C stored in plant biomass in oak dominated forests accounts for about 80% of the total C stored in vegetation, forest floor litter and soil (~ 30 cm depth), which is about 56% in pine forests.

The significant use of goods (e.g. fuel wood, fodder and leaf litter) provided by the oak forests has placed these forests under severe stress. As a consequence the good quality oak forests have been squeezed to a few mountain peaks physically inaccessible to the people, and pine, an early successional and fire adapted species, has colonised vast forest areas originally covered by oak (Singh and Singh 1992). The non-availability of much preferred oak has now compelled the inhabitants to depend upon the pine forests, considered inferior in terms of environmental benefits by the local people.

Ecosystem linkages between forests and agro-ecosystems

Traditional agriculture of Uttarakhand is the repository of agro-biodiversity. There is a rich diversity of crop plants (over 40 different crops and hundreds of cultivars comprising cereals, millets, pseudo-cereals, pulses and tuber etc.; Maikhuri et. al. 1997), deriving huge amount of nutrients and other services (e.g. sources of water for irrigation, pollination, etc.) from forest ecosystems. Furthermore, free grazing in the forests by livestock within traditional agroforestry systems in itself provides ES for agro-ecosystem functioning. Farmyard manure (consisting of animal dung, urine and forest leaf litter) is an important pathway for transferring nutrients from one ecosystem (forest) to another (agro-ecosystems) to replenish soil fertility (Figure 1).

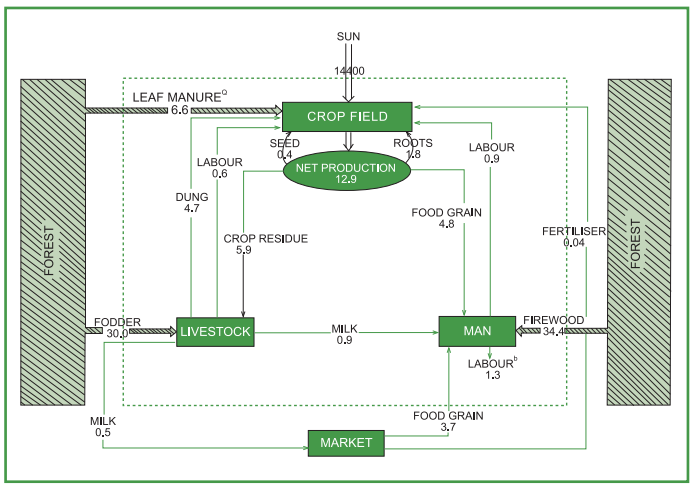

Figure 1: Energy flow through agroecosystems in the Indian Central Himalayan region. All energy values (x 10^6 kcal) are per ha of cropland (adopted from Singh and Singh 1992).

Studies on the quantities of biomass extracted for fuelwood, fodder, manuring leaves, wood for agricultural implements etc. from the oak and pine forests in Naugaon and Nanpapo villages (Table 1) show that in Nanpapo, the village dependent on oak forest, about 90% of the annual fuel wood consumption (177 t) and about 85% of the total fodder demand (1045 t per year) came from the forests. A total of 19 t manuring leaves were collected annually from forests in this village. Translating into monetary value (Singh et. al. 1992), fuelwood worth Rs. 87,615.00 (US $1864), fodder worth Rs. 40,964.00 ($872) and manuring leaves of Rs. 10,450.00 ($222) are extracted from the forests each year in this village.

In pine dependent Naugaon village, a total of about 120 t fuel wood and 175 t of fodder is consumed every year, of which only 25% and 23% respectively are contributed by the forests. The rest is met through crop residues. The annual monetary value of the fuelwood, fodder and bedding leaves extracted from the forests has been estimated to be Rs. 16,500.00 ($351), 22,138.00 ($471) and 6050.00 ($129) respectively for the entire village. In monetary terms the overall use value of forest resources is therefore nearly three times less than in the oak-dependent village.

Gaps in ES quantification and valuation: prospects for future studies

In the Indian context, both quantification and valuation of ES is an emerging discipline and has not been comprehensively attempted for Himalayan mountains, with the exception of a few isolated studies (Singh 2007, Verma 2000, Green Accounting for Indian States and Union Territories Project, 2004-2006, and Semwal et. al. 2007). This preliminary research highlights that the dependence of local communities on various provisioning services varies from one forest type to another. Comparative analysis of different types of forest ecosystems with regards to goods and services provided can inform policy and programmes for combining conservation, regeneration and productivity within agroecosystems. It is evident from the above discussion that oak forests are more important with regards to agroecosystem functioning as compared to pine forests, though in-depth studies are still required to support such a conclusion in different socio-economic and environmental settings in the Central Himalaya as a whole.

Promoting conservation, reforestation and sustainable management of oak forests in the region could be linked to a PES mechanism, with payments transferred through the village panchayats (VPs). Though fodder, fuel wood and leaf litter, in a strict sense, are ecosystem goods, over exploitation of these leads to declines in the generation of intangible benefits (ES) from forest ecosystems. In India, there is potential for a Government Operated Market for carbon sequestration, rewarding VPs for forest protection, and for integration of conservation activities within the National Rural Employment Guarantee Scheme. Local norms and practices to regulate the use and facilitate conservation of these valuable ecosystems should be internalised. Valuation of ES through all available instruments - education and awareness, economic, policy/law, and technology - must be attempted as a tool to foster sound environmental governance and for maintaining ecologically and socially valuable forest and agro-ecosystems in the Central Himalaya.

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Table 1: Biomass and energy flow from two different forest ecosystems to agro-ecosystems in Central Himalayan villages (after Ralhan et. al. 1991; Negi and Bhatt 1993).

Goods extracted from the forests	Biomass (useable weight, t / village/yr)		Energy value ($X10^6$ Kcal per capita/yr)	
Agro-ecosystem dependent on:	Oak Forest	Pine Forest	Oak Forest	Pine Forest
Fuel wood				
- Government forest	160	9	751.7	42.4
- Private support land	17	111	79.8	522.6
Total	177	120	831.6	565.0
Fodder				
- Government forest	904	22	851.6	20.7
- Private support land	141	153	132.8	144.1
Total	1045	175	984.4	164.8
Wood for agricultural implements	-	2	?	9.4
Manuring leaves	19	11	19	11.0
Minor Forest products	?	?	?	?
Monetary value of the resources collected from the forests (Rs./yr)	139,029 ($2958) 44,688.00 ($951)	-	-	

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