Valuation of Ecosystem Services and Forest Governance

A scoping study from Uttarakhand

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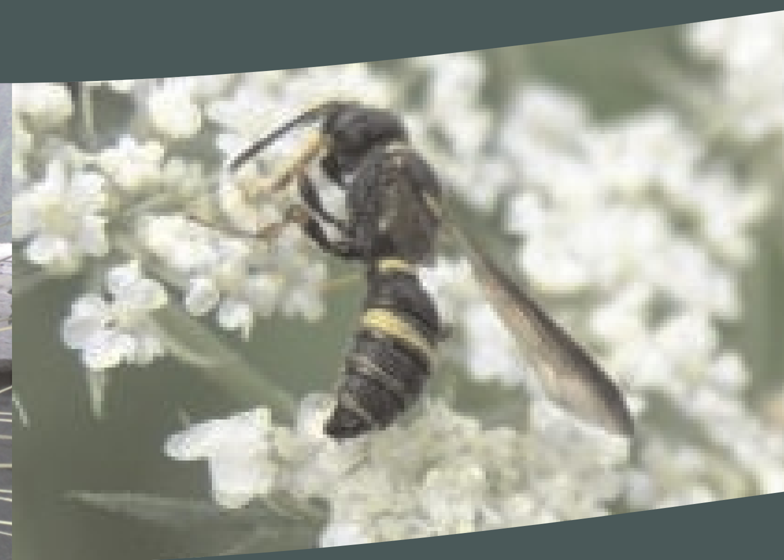

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Disclaimer:
This short-term scoping study is based on secondary information collated from various published/unpublished sources on forest ecosystem services of Uttarakhand. The team of researchers/editors do not claim originality in totality for the work presented here. Efforts have been made to cite appropriate source of information, however, we may have inadvertently missed citing of a few sources at certain places.

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List of Some Acronyms and Abbreviations

CAMPA	Compensatory Afforestation Fund Management and Planning Authority
CBOs	Community Based Organisation
CBT	Community Based Tourism
CSO	Central Statistical Organisation
CVM	Contingent Valuation Method
ESs	Ecosystem Services
FTC	Forest and Tree Cover
GBPIHED	Govind Ballabh Pant Institute of Himalayan Environment & Development
GDP	Gross Domestic Product
GISTP	Green Accounting for Indian States and Union Territories Project
GP	Gangetic Plain
GHGs	Green House Gases
GSDP	Gross State Domestic Product
Ha	Hectare
ICFRE	Indian Council of Forestry Research & Education
IIFM	Indian Institute of Forest Management
JFM	Joint Forest Management
MoEF	Ministry of Environment and Forests
NDP	Net Domestic Product
NGOs	Non Government Organisations
NPV	Net Present Value
NRA	Natural Resource Accounting
NSSO	National Sample Survey Organisation
NTFPs	Non Timber Forest Products
PA	Protected Area
PES	Payment for Ecosystem Services
PF	Protected Forests
PPM	Parts per million
PPP	Public Private Partnership
RF	Reserved Forests
SFD	State Forest Department
SHG	Self Help Group
SNA	System of National Accounts
TDRs	Timber Drawing Rights
TEV	Total Economic Value
UAFD	Uttarakhand Forest Department
VP	Van Panchayat

Acknowledgements

Ecosystem Services are essential for human survival. Though apparently look intangible, these are real benefits we all enjoy from healthy ecosystems that can not be taken for granted any more in present times. This endeavour in Uttarakhand is an attempt by LEAD India and partners to sensitize and raise awareness among the stakeholders on the value of these life supporting services that societies derive from forest ecosystems. The work presented here has been carried out by a multidisciplinary team drawn from various organizations which can be considered a unique effort in its own way. I congratulate the entire project team for all its hard work and completing such a complex and challenging task in most efficient manner. The enthusiasm of the project team can be gauged by the fact that during the course of the study the team not only collated information on some well known forest ecosystem services but also highlighted certain not so well known services of Uttarakhand such as forest succession and grazing in the report. The overview of the report highlights the significance of valuation of forest ecosystem services in Uttarakhand and suggests few ideas to share conservation benefits with local communities- the twin goals of sustainable development that LEAD as an institution is promoting since last many years.

I am indebted to Prof. S.P. Singh, eminent ecologist and the Vice Chancellor HNB Garhwal University who not only provided intellectual guidance and encouragements to the project team but also extended all his support to complete the study. He kindly agreed to write the foreword of the report and allowed us to use his concepts on valuation of ecosystem services presented before 12th Finance Commission of Government of India by the Government of Uttarakhand.

In Uttarakhand, I extend my sincere thanks to Ms Vibha Puri Das, Principal Secretary and Forest and Rural Development Commissioner; Mr. N. Ravichandran, Principal Secretary; Dr. B.S. Burfal, Principal Chief Conservator of Forests; and his colleagues at Uttarakhand Forest Department; LEAD Fellows and Senior Forest Officers Mr. D.V.S. Khati and Mr. B.M.S. Rathore for showing keen interest in the study and providing constructive comments and support.

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On behalf of LEAD India I wish to thank all the scientists and scholars whose work secured from various secondary sources have been utilized to prepare this report. I would be failing in my duties if the keen interest taken by the Government of Uttarakhand especially the Forest Department is not acknowledged.

I hope the information generated during present short-term study will be utilized for education and awareness purposes around this new theme, and also in stimulating the debate on how to take these natural services into account for conserving ecosystems and ensuring local livelihoods.

Pragya D. Varma

Executive Director

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Foreword

It is only during last decade or so the term " Ecosystem Services" has found place in literature relating to ecology, economics and conservation. Economists have used it more frequently particularly since the publication of the famous article of Costanza and others in 1997 on economic value of ecosystem services at the global level. Payments to those who contribute to maintain the flow of ecosystem services are in place in some parts of the globe. In most payments, governments have played a significant role. It is often suggested that as long as ecosystem services are not included in market system, governments should incorporate them in their accounting systems so that the service providers have economic rewards for their conservation efforts. With regard to payment for ecosystem services, one of the major problems is how to measure the value of ecosystem services flow in ecological and economic terms. Then, there is a need to develop methods that monitor impacts of a given economic regime on the flow of ecosystem services.

A region needs to have ecosystems of varied attributes, such as productive, protective and waste assimilative ones. The agriculture system has primarily a productive role, the old growth-forest plays a major function of regulating hydrology and climate, and the wetlands dissipate wastes that an urban system generates. The proportion of each type in a given region would depend on health of these ecosystems, energy and matter used by humans, energy use efficiency and several other factors. Planners will have to consider all these factors for achieving sustainability.

There are certain areas which are primarily providers of ecosystem services, whereas others benefit from them. Through its river connections, Uttarakhand is a principal provider of forest ecosystem services that keep on replenishing the productivity of stressed agricultural fields of the Gangetic Plains. This significance of Uttarakhand was one of the principle reasons for its inclusion in the present study.

This report is an analysis of information compiled on important ecosystem services that flow from the forests of Uttarakhand Himalaya. These services are of wide range so far as their spatial extent is concerned. For example, much of non-timber forest products are of direct use to local people, watershed services have relevance to local as well as regional population, and carbon sequestration has global significance. In this short-term preliminary study, investigators mainly depended on the secondary sources for information. However, they also collected data for certain relevant parameters. It is hoped that this report would prepare a ground for further efforts in the direction of quantification of the flow of services both in ecological and economic terms, measures required to make sustainable use of services, and payments or reward to local people for their efforts towards conservation of forests in the state.

The project activities also included interaction with the officials of the state forest department. It is heartening to note that they are getting increasingly familiar with the issues of forest ecosystem services which is a major advancement in the field of conservation. They, particularly Madam Vibha Puri Das, the Principal Secretary & Forest and Rural Development Commissioner, were keen to give a practical shape to the mechanism of payment for ecosystem services generated by Van Panchayat forests. How to measure the conservation efforts of local people is a major bottle-neck. The problem is that the community forests vary widely in size from one village to another. A community forest may be in a good shape if its size is large relatively to population even when people do not take enough conservation initiatives. In contrast, people's efforts would not be visible when forest size is very small relative to population. Getting payment for protecting a standing forest represents a quantum jump in the area of forest conservation.

Saving Carbon by avoiding deforestation is not included in Kyoto Protocol, but continues to be a major issue of discussion worldwide. It is possible to connect Carbon sequestration to schemes like 100 days employment guarantee of the government. In our internal arrangement, payments for Carbon sequestration both by new plantations and standing old forests could be included to promote conservation of forests and flow of ecosystem services from them. Valuing local actions to save global environment is not only justified on equity ground, but it also creates a romance of global partnership. It must be taken note that the per capita emission of CO_2 per year by these people is around 0.1 - 0.2 t, far lower than per capita global average, 4 t yr^{-1}.

One way of payment could be to make modern cooking energy accessible to local impoverished people as an economic incentive for their contribution to forest conservation. The concept of valuation of ecosystem services, as this report indicates, may lead to many such ideas concerning participation of the last of people in global issues of sustainability, governance, and equity. I hope, the study would lead to formulization of a larger project concerning this new approach of forest conservation.

The report has been quite successful in pinpointing a few major gaps in knowledge and measures that could be taken to address them. The investigators have made progress in several areas connected to ecosystem services, many of which have not been considered in other studies. I hope the initiative will go a long way to improve our understanding of one of the most important areas of environmental sustainability. The funding agency, I hope will be pleased with this progress. LEAD India did a good job in involving stakeholders and experts of varied backgrounds in the present study such as local members of village forest councils, scientists, government forest managers, grassroots level NGOs and top officials. The project gave an opportunity for some very talented young persons to work together for the cause of conserving precious Himalayan forest ecosystems e.g., Rajeev Semwal of LEAD India, Rajesh Thadani of CEDAR, Pushkin Phartiyal of CHEA, Ashish Tewari of Kumaun University and Girish Negi of G.B. Pant Institute of Himalayan Environment and Development.

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Chapter 1

Valuation of Forest Ecosystem Services in Uttarakhand: An Overview

Human societies derive many essential goods from natural ecosystems, such as food, fodder, fuel wood, timber, and non timber forest products including medicinal plants. These goods now categorised under provisioning services represent well known ingredients of the economy. What have been less appreciated until recently are the intangible (or indirect) but real and life supporting ecosystem services associated with a forest ecosystem without which human civilization can not survive. According to the contemporary thinking, these ecosystem services (ESs) may be categorised as: (i) regulating, such as climate moderation, disease and pest control, pollination, and hydrological regulation; (ii) cultural, like recreational, spiritual, educational, and aesthetic; and (iii) supporting services such as soil formation, nutrient cycling, biodiversity and succession (Millennium Ecosystem Assessment, 2003). Thus, ecosystem services are defined as ***a wide range of conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life*** (Daily, 1997).

Ecosystem Services are generated as a consequence of interaction and complex exchanges between biotic and abiotic components of an ecosystem through the universal driving forces of matter and energy (Singh, 2002; Rudolf *et. al.*, 2002). In other words ecosystem functions (such as nutrient cycling and biomass productivity) generate ecosystem services but it is not always necessary that they show a one to one correspondence (Singh, 2002). Such ecosystem processes are worth many trillion dollars annually (Costanza *et. al.,* 1997). Yet most of these benefits carry no price tags that could alert society to changes in their supply or deterioration of major ecological systems that generate them. We take these benefits for granted without caring about their genesis and therefore do not think about conserving them. In spite of knowing that economics of the world would come to a halt without ESs, their indicative values in monetary terms have been estimated only recently (Daily *et. al.,* 1997). One of the most comprehensive exercises carried out by Costanza *et. al.* (1997) involving experts with backgrounds ranging from economics to ecology identified 17 types of ESs across various ecosystem types, including 14 from forest ecosystems. The analysis estimated the current economic value of the services provided by the earth's ecosystems at least at US$ 33 trillion yr^{-1}.

Across the globe in the wake of ever escalating human activities, there is a critical need for identification and monitoring of ESs both locally and globally, and for the incorporation of their value into decision-making processes. The concept of valuation of ESs is increasingly becoming popular since last one decade. The release of the Millennium Ecosystem Assessment (2005) was an important milestone that stressed the need to better describe, quantify and value (ecologically, culturally and economically) the ESs. In order to make comparative ecological economic analysis possible, a standardized framework for the comprehensive assessment of ecosystem functions, goods and services is the need of present times (Rudolf *et. al.,* 2002). However, based on available scientific evidences we can certainly make three general statements **i)** ESs are essential to human civilization; **ii)** these operate on such large scale, complex and little explored ways that most can not be substituted by human endeavours or available technology; and **iii)** human activities are already damaging the flow of ESs on a large scale.

Developmental activities such as large-scale land use changes, degrade forest ecosystems and hence ESs which in the long-term outweigh the tangible short-term economic benefits from such activities. Through appropriate and timely interventions these ecosystem functions can be restored (Daily *et. al.,* 1997).

Ecosystem services are often in flow and their valuation depends on societies living both inside and outside the ecosystem. Valuation, however, is greatly influenced by human perceptions, level of awareness and education, and institutional context (Singh, 2002). The impact of increasing awareness on the value of ESs throughout the world is resulting in societies and institutions gradually turning towards ecological approaches to find sustainable solutions for socio-economic development. At present there exist a number of examples across the globe where such approaches have been successfully demonstrated (See Chapter 3 for more examples). A famous example worth mentioning is of the New York City water department which chose to invest $ 1.5 billion to conserve the Catskill natural watershed rather than spending a huge amount ($ 6 billion) to construct a new water treatment system (as quoted by Singh, 2002). Many types of markets viz., Mitigation Markets, Business-to-Business Markets and Government Payment Markets are slowly coming up where ESs are transacted and valued in monetary terms. It is interesting to note that all these markets have two things in common: first the central role of government, and second - most successful service markets operating at present, function as monopsonies, with a dominant buyer for multiple service providers (Salzman, 2005).

Valuation of Forest Ecosystem Services in the Context of the Himalaya

The Himalaya is the youngest and loftiest mountain chain in the world and considered to be the water tower for a majority of the population of south Asia. From an ecosystem services stand point the Himalayan mountains are of critical importance not only to the Himalayan people but also to a significant proportion of the global population. Forests of the Himalaya are rich in biodiversity with 10,000 species of vascular plants, 13,000 species of fungi and 1,100 species of lichens. There are 240 species of mammals, 750 species of birds and 270 species of fishes (source: Report of the Task Force on Mountain Ecosystems to Planning Commission, Government of India, 2006). The Himalayan forests help maintain soil fertility and essential atmospheric moisture in the adjacent vast Gangetic Plains through numerous river connections that originate from these mountains, and help minimize erosion and downstream sedimentation (Bruijnzeel and Bremmer, 1989). The mountain agroecosystems (the mainstay of mountain people) are heavily subsidized through biomass/energy transfer from the surrounding forests (Singh and Singh, 1992) that provide food security and also maintain land races of food crops.

In spite of the crucial ecological, cultural and economic importance of the ESs, ecosystems are deteriorating in the fragile environment of the Himalaya. The value of the ecosystems to human welfare is still underestimated and the ESs are at best only partly captured through conventional economic instruments. Available mechanisms and measures of development, including the current SNA (System of National Accounts) with its primary focus on GDP (Gross Domestic Product) growth rates, do not capture many vital aspects of national wealth including changes in extent of environmental resources. Although, ESs are widely perceived and recognized, they are poorly understood. Often there is neither a reward for the safeguard nor any punishment system for the destruction of these ESs. Valuation can help identify the main beneficiaries of conservation and the magnitude of the benefits and contribute to financing of conservation - A concept known as payment for ecosystem services (PES).

There is a need for an experimental basis on which to base policy decisions on the trade-offs between the many competing priorities of a developing nation, including claims of present and future generations. The national GDP accounts and its state-level equivalent GSDP (Gross State Domestic Product) accounts are, therefore, not sufficient for adequately evaluating the trade-offs that policy-makers generally come across. The existing GDP growth percentages used as yardsticks to measure development and well being of citizens in decision making processes are substantially misleading, yet they continue to be used for doing so by all concerned (Haripriya *et. al.*, 2006). Valuation of Ecosystem services to build a framework of adjusted national accounts will show, in economic terms, the depletion of natural resources and the health costs of pollution, and it will also help raise awareness. The indicators namely human development index and environmental sustainability index reflect on qualitative measures of sustainability. Valuation of ESs can be utilized as a quantitative tool to evaluate the sustainability of the development interventiones. It has the potential of providing an unbiased and dependable national framework to value so far unaccounted ecosystem benefits and also to utilize existing research outputs in a manner that makes it useful for developing meaningful policy interventions (Haripriya *et. al.*, 2006).

In India, quantification and valuation of ESs is an emerging discipline and has not been comprehensively attempted so far in Uttarakhand except for a few preliminary studies by Singh *et. al.* (1992); Singh, (2002); Singh *et. al*. (2003); and Negi and Agarwal (2006). Valuation of ESs through all available instruments such as awareness and education, economic, policy/law, and technology may be utilized as a tool to foster good environmental governance. However, this is easier said than done as experts are still trying to understand the finer details of valuation and institutional mechanisms needed to use it as a tool for conservation and livelihood security of local communities. Valuation of ESs is a balanced approach for conservation of ecosystems that calls to conserve whatever remains and restore areas where it is possible, rather than spending time and resources on selecting biodiversity rich areas. To enable these services of great intrinsic value to command price calls for radical change in thinking and development planning.

Despite making considerable contribution in Uttarakhand's economic and ecological systems, the forests of the state do not get proper recognition of their contribution in the State Domestic Product (SDP) in the absence of proper valuation and lack of information to decision makers. Its contribution reflected in the SDP is only 3.50% (Rs.5109.6 million) as only few goods and services from forest of Uttarakhand are marketed and thus accounted in the current calculus of SDP of the state (Verma, 2007 Present Study, Chapter, 3).

Present Initiative: Why Uttarakhand?

Understanding forest ecosystems services and their valuation, considering the direct, indirect and existence values is crucial, particularly in the context of Uttarakhand Himalaya where about two-thirds of the land is under forests and large chunks of forests are suffering varying degrees of degradation due to pressures emanating from various anthropogenic activities. The state of Uttarakhand is rich in endemic biodiversity and the forests provide ESs of high magnitude to the Indo Gangetic Plain (GP) in terms of regulated supply of water and nutrients rich soil through its river connections, thereby sustaining the livelihoods of about 500 million people inhabiting the area. Livelihoods for more than five million mountain dwellers are also mainly forest based. For these reasons, Uttarakhand has been chosen for the study.

There is a distinct social awareness particularly among rural women on the life supporting importance of forests in the state that can be judged from the origin of the famous Chipko (hug the trees) movement from the region. Well known Chipko leaders Sri Sunderlal Bahuguna, Sri Chandi Prasad Bhatt and numerous other volunteers helped spread the message of the movement far and wide. The famous Chipko slogan *"Kya hain jungle ke upkar, mitti pani aur bayaar, mitti, pani aur bayaar, jinda rahane ke adhaar"* (how do the forests benefit us? they provide soil, water and pure air that are the basis to sustain life) aptly describes the value of standing forests in providing ESs. This movement of Uttarakhand helped in catalysing the change in national and international view point on the role of forests in sustainable development and hence developing conservation policies (Shiva and Bandyopadhyay, 1986; Guha, 1989). Uttarakhand is also well known for the struggle to protect and conserve the forest resources right from the colonial period leading to the formation of one of the oldest community forestry institutions in the world called Van Panchayat where local communities manage over half a million hectares of forests through state support. Ecological constraints and opportunities have given rise to a social system which is dependent on forests and other natural resources. However, with the changing times, many traditional social values, institutions and practices that ensured livelihood security to various social groups and conservation of natural resources through collective actions are gradually waning. In addition, the state had a long legacy of playing a venue for conservation related activities such as the creation of the first National Park (Corbett National Park) in 1936 and launch of Project Tiger in 1973 in India, and it also has a large pool of forest and environment related institutions such as Forest Research Institute, Forest Survey of India, Wildlife Institute of India, G.B. Pant Institute of Himalayan Environment and Development (GBPIHED), several universities and scientific institutions.

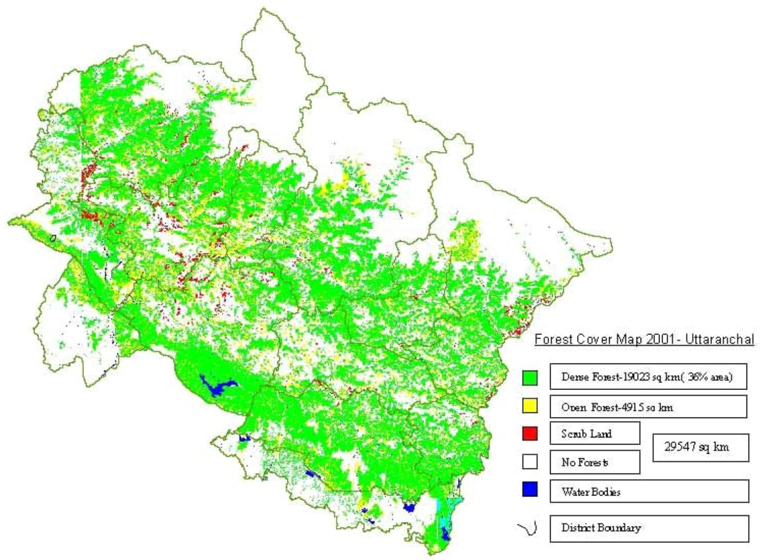

Fig. 1.1: Forest Cover in Uttarakhand 2001
Source: www.uttarakhandforest.org

All these historical, geographical, social, forest resource richness, and institutional advantages make the state of Uttarakhand an obvious choice for the present short-term scoping study to be under taken here on valuation of forest ecosystem services. The initiative is based on collation of secondary information on important specified forest ESs viz., Carbon sequestration, hydrological regulation, scenic beauty and recreation, non timber forest products, agrobiodiversity, and pollination. The collected information has been analyzed in order to understand how various stakeholders and communities may be involved more effectively in conservation and management of the forests, highlight knowledge gaps, and prepare a suitable platform to attempt realistic valuation of the ESs in near future. In addition, information has also been collected on the role of Van Panchayats to understand local forest governance issues and on some not so well known forest ESs - such as role of forests in landslide/land slip stabilization (succession), grazing, and goods and services people derive from oak and pine forest&the two dominant forest types in Uttarakhand. Based on secondary information an attempt has also been made to develop various indicative economic valuation scenarios for various forest ESs of the state.

The present document may give an impression that the information presented under various chapters is disjointed or unconnected. However, a strong thread that makes them seamlessly inter-connected is that each chapter describes one or the other important forest ecosystem service of Uttarakhand.

Uttarakhand: Some Relevant Facts

Uttarakhand, the seven year old 27th state of the Republic of India, lies between 28^{0} 43$'$ and 31^{0} 27$'$ N Latitude and 77^{0} 34$'$ and 81^{0} 02$'$ E Longitude. The total geographical area of the state is 53, 483 km^2 of which approximately 89% is mountainous. The river Tons separates the state from Himachal Pradesh in the west and the river Kali forms the international border with Nepal in the east. Starting from the foothills, that form its southern boundary with the state of Uttar Pradesh, the region extends up to the eternal snows forming the Indo- Tibetan border in the north. In the long sweep of the entire Himalaya, Uttarakhand is located centrally and enjoys the transition between the humid east and sub-humid to semi arid western Himalaya (Nandi *et. al.,* 2006). The total population of Uttarakhand is 8.5 million of which little over 5 million people live in the mountainous parts of the state. Thus, this predominantly mountainous state has rich biodiversity both wild as well as domesticated (agrobiodiversity). It has about 65% of the total geographical area under forest of which 40% is under good forest cover. Administratively the state Uttarakhand is divided into two divisions viz., Garhwal and Kumaun and 13 districts viz., Almora, Bageshwar, Chamoli, Champawat, Dehradun, Haridwar, Nainital, Pauri, Pithoragarh, Rudraprayag,Tehri, Udhamsingh Nagar and Uttarkashi.

Forests are obviously one of the most important resources of Uttarakhand and have a direct role in supporting rural livelihoods in the state not only by meeting the people's day to day needs of fuel, fodder and timber but also by providing employment in some areas. Agriculture is one of the core economic activities for over 80% of population. Agriculture, forest, and animal husbandry form an interlinked production system and the role of forests in sustaining the agriculture and animal husbandry systems is immense. The three basic farming systems viz., settled agriculture practiced by a vast majority of traditional farmers; transhumance by small Bhotiya community; and nomadism by even smaller Van Gujjars, are all dependent on surrounding forests for various resources (Singh *et. al.,* 1984; Semwal *et. al.,* 2001). Settled agriculture, a mixed crop livestock farming system is practiced by nearly five million traditional farmers inhabiting the mountainous parts of the state with approximately 6000 km^2 under net sown area category. Apart from Bhotiyas and Van Gujjars, other small social groups like Van Rajis, Taungyas, Gothias of Uttarakhand and shepherds known as Gaddis of Himachal Pradesh are also dependent on the forest resources of the state for part of their livelihoods.

According to the forest classification of Champion and Seth (1968), along an altitudinal gradient ten different forest types can be identified in the state. Some of the most prominent forest types are sub tropical chir pine, tropical moist deciduous, Himalayan moist temperate, tropical dry deciduous, and Himalayan dry temperate forests. These forests spread over 34,650 km^2, out of which the State Forest Department (SFD) controls about 70% forest area of the state and are managed as Reserved Forests, Protected Forests, and under various categories of Protected Areas (Table 1.1). The SFD manages these forests under a total of 13 Forest Circles, 48 Forest Divisions, and 284 Forest Ranges following the rules and regulations of Indian Forest Act, 1927, Forest Protection Act, 1980, Wildlife Protection Act 1972, and Biodiversity Protection Act, 2002. The mountainous parts of the state are important as these are endowed with rich biodiversity having species from subtropical to alpine zone. Sal (*Shorea robusta*) forests in the foothills, chir pine (*Pinus roxburghii*) between 800 and 1600 m, and oaks (*Quercus* spp) between 1600-2600 m are the dominant forest species. Of the total forest area under the control of SFD, the area occupied by sal forest, chir pine forest, and oak forests is 3151.12 km^2, 3993.3 km^2 and 3000.72 km^2, respectively. Further at high elevations deodar (*Cedrus deodara*), blue pine (*Pinus wallichiana*), cypress (*Cupressus torulosa*), fir (*Abies pindrow*) and spruce (*Picea smithiana*) together cover nearly 6% of the total forest area.

The remaining forest area is under the management of local forest institutions known as Van Panchayats (15.73%), State Revenue Department (13.76%) as Civil and Soyam forests, and a very small area (0.46%) under the control of other institutions and privately owned with their respective management norms and practices. The VP forests occupy approximately half a million ha area being managed through more than 12,000 VPs. Though based on general observations and inferences drawn from other studies, it is believed that the forests managed by VPs are generally in better ecological conditions than those managed under other regimes, comprehensive studies are still lacking to support these observations conclusively. The VPs play a crucial role in meeting the resource needs of the local communities and avoiding deforestation at the same time. In the present situation many questions have to be answered on the sustainability of VPs linked with policies, socio-economic changes and other ground realities (See Chapter 5 for details)

Tree and forest soils sequester a huge amount of Carbon

Many of the biomass and productivity values of the forests of Uttarakhand are on the higher side of ranges for a given forest type found elsewhere, productivity is relatively high for the biomass present, and the potential regional productivity appears to be above that previously predicted from measurements of climate (Singh *et. al.,* 1994). The area between the timber line (>2800 m amsl) and snowline is represented by vast stretches of alpine meadows locally known as Buggyals that provide an additional ecological dimension to the forests of the state. These buggyals and adjacent sub-alpine forests are not only of unparallel scenic and aesthetic value but also harbor many life saving medicinal plants (e.g., *Taxus baccata, Podophyllum hexandrum, Picrorhiza kurrooa, Aconitum heterophyllum, A. balfourii* etc.).They are also habitat to some endangered wild animals; serve as seasonal grazing grounds for large number of livestock, and are known historically as a sacred land for saints, trekkers, and nature lovers (See Chapters 2 & 4 for details). The alpine meadows, providing various ESs are going to be the hub of activities with rising global temperatures, because of the upward march of species and humans.

Table-1.1: Some Relevant Information on Uttarakhand (based on Uttarakhand Forest Statistics, Forest Department, Uttarakhand 2005-06; * As per SFR, 2003, and Nandi *et. al.*, 2006).

S.No.	Details	Area/Number
1	Geographical area of Uttarakhand (km^2)	53,483
2	Population (No.)	84,89,349
3	Rural Population %age	74.41
4	Number of districts	13
5	Agricultural land as %age of total geographical area	14.25
6	Total forest area (km^2)	34,650
7	Per capita forest area (ha)	0.41
8	Total forest area as percentage of geographical area	64.79
9	Total forest area under forest department according to legal status (km^2)	24413
10	Forest area legally under forest department as percentage of geographical area of Uttarakhand	45.65
11	Total forest area under the management of forest department (km^2)	24,273
12	Forest area managed by forest department as percentage of Geographical area of Uttarakhand	45.38
13	Area under Forest Cover as % of geographical area of Uttarakhand*	45.74
14	Area under forest cover as % of total forest area of Uttarakhand	70.58
15	Area under Forest and Tree cover (km^2)	25,036
16	Area under Forest and Tree cover (% of geographical area of Uttarakhand)*	46.81
17	Number of Protected Areas (National Parks, Wildlife Sanctuary and Conservation Reserves, and forest area under PAs in km^2)	14, (7418)**
18	Pasture land (km^2) legally under Forest Department	1,487
19	Snow covered Forest Areas legally under Forest Department (km^2)	3,103.7
20	Forest Revenue and total Expenditure (2005-06) Million Rupees	1,510.6 (3,135.6)***
21	Major Rivers	Ganga, Yamuna, Sarju and Kali
22	Major source of occupation	Agriculture, Forest based activities

** Area under PAs (km^2), ***Total (plan and non plan) forest expenditure

The mammalian diversity in Uttarakhand is one of the richest in the country with over 75 species, out of which half are endangered. This young state can take pride in the fact that more than 14% of its geographical area is under formal and informal Protected Area (PA) network, indicating the rich biodiversity that occurs along the altitudinal gradient. While the PAs located in the bhabar and foothills such as Corbett Tiger Reserve are famous for large mammals including flagship species like tiger and elephant, the high altitude PAs such as Valley of Flower National Park are world famous for their scenic beauty.

A Synopsis on the Value of Forest Ecosystem Services

The state of Uttarakhand lying in the central Himalaya has a high ecosystem value with over 40% area under good forest cover and also because of its river connections nurturing a large territory downstream the Gangetic Plain (GP). There is no such receiver territory for ecosystem services in eastern Himalaya though this area is given higher priority internationally for conservation. Thus, the forest ecosystems of Uttarakhand play a major role in the ecological security of India. The forests of Uttarakhand contain 496 million **t** C in their biomass and soil components and contribute significantly in terms of Carbon sequestration which has great significance from a climate change stand point.

There is a need to take immediate initiative to enable the marginal mountain people of Uttarakhand to conserve these forests. The people depend on these for day-to-day living, collecting biomass to meet their needs of firewood, fodder, leaf litter and other NTFPs. Large forest areas near village are left with only denuded forest cover because of lopping of branches and twigs. However, even these forests are important from C-credit point of view because they have a large amount of C-sequestered in their standing boles. (See Chapter 2 for details).

Apart from C-sequestration the forests of Uttarakhand play a significant role in providing ESs to the adjacent Gangetic Plain (GP), one of the most productive agricultural areas of the world. Though the formation of the great GP was a geological process; ESs flowing from the Himalaya have played a pivotal role in making it fertile and robust (Fig. 1.2). The principal forest ESs include soil formation, hydrologic regulation, and maintaining suitable moisture regimes for the rich and highly endemic biodiversity and maintenance of productive agriculture in the GP. These ESs are important for the well being of not only 500 million people living in the GP but also for over five million local farmers of Uttarakhand as the traditional agriculture is heavily dependent on surrounding forests for resources. According to an estimate, to generate one unit of energy from agriculture, 10-12 energy units of forest biomass are required. According to a rough estimate, contribution of forest ESs of Uttarakhand to food production in the GP is worth about Rs. 10-50 billion annually. These figures simply indicate a cautious guess. The maintenance of genetic diversity of crops, livestock, fodder plants, soil microbes, and organically produced food grains and pulses in the traditional mountain agriculture of Uttarakhand can also be recognised as services provided by the forests.

Although, it has not been possible yet to give precise estimates of the magnitude of ESs flowing from Uttarakhand to GP, there are certain evidences as given below that testify their value:

1. High water status in lowland forest ecosystems than in highlands despite lower precipitation. For example, though the sal forest in the plains receives 100 cm less rainfall than the forests in Nainital catchment, the water potentials both in soil and trees are significantly higher in sal forests largely because of the downstream movement of water, soil and nutrients resulting in a high productivity.
2. Increase in proportion of sand and gravel in downstream areas subsequent to deforestation upstream. The grasslands in plains adjacent to mountains are among the most productive ecosystems of the world.
3. In many parts of the world (e.g., western coastal United States), ecosystem productivities are much lower in plains than in adjacent mountains (Zobel *et. al.* 2001). In some regions, desert vegetation in plains surrounds forest vegetation in mountains. In contrast, in the plains of the Himalayan region productivity is generally greater than in the mountains, indicating an effective downstream flow of ESs.
4. Resumption of crop cultivation in the plains immediately after scooping out one meter of soil for brick making is testimony to the build up of soil fertility.
5. Crop cultivation in GP for several thousands of years without widespread degradation has been possible because of the ongoing replenishment of soil and its fertility from the mountains.

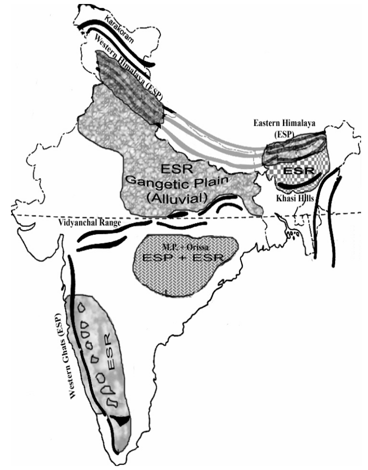

Fig. 1.2: A representation of principal ecosystem service providing (ESP) regions of India and adjoining service receiving regions (ESR). Areas outlined are approximate. These ESPs are also important in regard to terrestrial biodiversity. Western Ghats and Eastern Himalaya are among the top 25 hotspots. Though not equally important in terms of biodiversity the Western Himalaya exceeds considerably the other regions in terms of ecosystem services, largely because of the large associated territory and river connections.

Valuation of Forest Ecosystem Services

A reasonably detailed Carbon dataset for various forest types of Uttarakhand is available. In least disturbed forests of various types, such as sal (*Shorea robusta*), pine (*Pinus roxburghii*) and oaks (*Quercus* spp) forests Carbon sequestration rates in total biomass range between 4.0 *and* 5.6 **t** C ha^{-1} yr^{-1}, which are reasonably close to values reported for tropical forests. However, these high rates are not found everywhere, and for some areas forest types may reflect a range between 2.5-3.5 **t** C ha^{-1} yr^{-1}. The amount of Carbon accumulated in total forest biomass in the state is estimated at 6.61 M **t** yr^{-1}, and valued at Rs. 3.82 billion at the rate of US$ 13 per t Carbon. Soil Carbon pool is as large as the biomass Carbon pool, but the rate of sequestration in the soil is not known.

As mentioned, apart from Carbon sequestration, there are various other ESs generated by forests of Uttarakhand. Some of them, such as genetic resources and recreation are of global significance, while others are useful to local and regional people, or are of national significance. (Table 1.2).

Table 1.2: Characteristics of Studied Forest Ecosystem Services

Sl	Ecosystem Service	Observation on economic valuation	Benefits			
			Local	Regional	National	Global
1	Carbon Sequestration	A				√
2	Landscape Beauty/Recreation	A	√	√	√	√
3	Agrobiodivesity	A*	√	√	√	√
4	Soil Formation/ Fertility Maintenance	A	√	√		
5	Hydrological Regulation and Climate Moderation	B, A*	√	√		
6	Succession (Land slide/slip stabilization)	B	√			
7	Pollination	B	√	√		
8	Non Timber Forest Products	A	√	√	√	
9	Grazing	B	√			

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A= Valuation Possible; B= Valuation Possible but sufficient information is not available; A= certain components could be valued monetarily but complete may need other valuing instruments.*

Ecosystem valuation is difficult and fraught with uncertainties. Though the figures of Costanza *et. al.* (1997) are global yet from them one could draw some conclusions for the forests of Uttarakhand Himalaya. For Uttarakhand forests, we used the mid-point (Table 1.3) of the values estimated for tropical forests (US$ 2007 ha^{-1} yr^{-1}) and temperate/boreal forests (US$ 302 ha^{-1} yr^{-1}). In terms of species richness, the Himalayan forests are closer to temperate forests but in terms of ecosystem functioning they are closer to tropical forests (Zobel and Singh, 1997). Since the latter factor is more important in relation to ESs by taking mid-point values we are underestimating the value of the forest ESs from Uttarakhand. It was considered safe to take a conservative value.

Table 1.3: Annual Value of Various Forest Ecosystem Services of Uttarakhand (the mid point values given below were calculated from various parameters given for tropical and temperate forests in Costanza *et. al.*, 1997).

Ecosystem service	Value in US$ ha^{-1} yr^{-1} (US$ 1 = Rs. 44.5)
Climatic regulation	167.6
Disturbance regulation	2.3
Water regulation and water supply	5.2
Erosion control	114.6
Soil formation	11.6
Nutrient cycling	429.6
Waste treatment	102.7
Biological control	2.3
Food production	50.7
Raw material	164.0
Genetic resource	18.5
Recreation	78.6
Cultural	2.3
TOTAL	**1150**

As shown in Table 1.3, with an average value of about US$ 1150 ha^{-1} yr^{-1} the total value of the ESs from the forests of Uttarakhand (area 2352700 ha, P.S. Roy and P. Joshi, unpublished data as quoted by Singh S.P. 2007) is approximately US$ 2.4 billion yr^{-1} or Rs. 107 billion yr^{-1}. Of these, the Carbon sequestration services account for only a small fraction, 5%. It is worth considering to what extent Costanza *et. al.* (1997) considered Carbon sequestration and whether it was part of climatic regulation or biogeochemical cycle or both. At the time they undertook their study Carbon sequestration was not valued as it is being valued under the various mechanisms of Kyoto Protocol. Therefore, they could have undervalued Carbon sequestration. Costanza *et. al.* (1997) did not consider certain services like natural colonisation of bare sites by plants and subsequent succession which plays an important role in the recovery of ecosystems in the Himalayan region where landslide/landslip erosion and other soil mass movements are frequent.

Ecosystem Services those are Difficult to Value - Moderation of Regional Climate

Recent findings clearly indicate the importance of forest cover on the Himalayan slopes in moderating the climate of the Indian sub-continent. Much of the high humidity of the GP is due to the forest cover of the Himalaya. Delhi's humidity, for example, is very high considering that from the standpoint of precipitation it is a semi arid place. In contrast to the temperate regions where forest cover is limited to 1000-1500 m altitudes, in the Himalayan region forests clothe the slopes even beyond 3000 m altitudes. A high humidity level plays a significant role in promoting growth of both cultivated food crops as well as trees. Valuation of these services is difficult because several other factors can suppress their effects, nevertheless they are real, and could be made apparent through focused research.

Numerous water sources create moist condition in the Himalaya- An Ecosystem Service difficult to value

Sharing of Ecosystem Services

Mechanism of economic compensation should be developed by the nation to enable the people of Uttarakhand to sustain their conservation activities, and not turn into an exploitative community by effecting such landuse changes which may impair the flow of services within and outside the region.

Costs of products such as agricultural crops, hydroelectricity, and domestic water supply in cities, the supply of which depends partly on upstream ESs, would be much higher if these services were accounted for in economic terms. However, human societies cannot afford to ignore the contributions of ESs, and efforts are required to do their valuation at all spatial scales (local, regional, national and global), and identify the regions from where they flow and those who are the beneficiaries. These would be needed to develop a fair accounting system for appropriate mechanisms of economic transfer from the consumers of the ESs to those who help conserve their generating processes. The market does not perform this transfer at present; therefore this function needs to be taken over by the state. In the case of Himalayan states, which are almost exclusively providers rather than consumers of ESs, the most appropriate mechanism would appear to be a centre-state money transfer in which the funds from general revenue at national level (representing the consumers) is ploughed back via the states into forestry sector at the local level in the Himalaya, such that the conservation benefits could be shared with local communities. For example, in case of Himalayan states it may be important for local people to have access to modern energy sources to enable them to keep forests conserved. Suitable mechanisms would be required to ensure that the local communities have share in the money that is transferred from centre to the states.

Ecological Security, Equity and Justification for Compensation

A country requires a balanced mix of ecosystems that take care of food production and of those which give ecological security to it. The ecosystems that dominate in the Himalayan states in general and in Uttarakhand in particular belong to the second category i.e. providing ecological security. It is, in part, because of their ecological services that India has one of the largest areas under productive ecosystems (agricultural land) in the world.

Whatever success the people in mountains have achieved in conserving their forests, they have been able to do so without any access to modern energy sources. From the equity point of view alone, the poor people in the Himalayan states should be given support to have alternatives to biomass fuel, so that they have some modern content in their lives. It involves also the issue of gender equity, for it is the women who suffer most due to the lack of support to these areas. They do much of the hard work of collecting resources including biomass for cooking, fodder for livestock, leaf litter for animal bedding to prepare farmyard manure (FYM), all the major drudgery driven activities related to agriculture and thus live a hard life exposed sometimes to unhygienic conditions. High quality Cars carrying tourists can be seen on roads along with modern tourist resorts in Uttarakhand where women still climb trees for collecting low quality fodder for their low quality animals, a practice that has persisted since many centuries. According to a report, 1.6 million women die prematurely in the world because of the pollution created by the use of biomass for cooking (Singh, 2007). In an economic model based on consumptive traits (which is being followed in the country), efforts have to be made to minimize their drudgery and improve the quality of life of a large number of hill women living in the villages.

Lopping of oak trees for fodder is mainly done by women in rural areas which is an arduous activity and fraught with many dangers

Fetching fodder and fuel wood from forests are other labourios task performed by rural women

Steps should be taken to replace the use of firewood by modern energy sources, so that the forest ecosystems continue to generate the ESs including Carbon sink benefits, and the women and people in the state have a better health condition and time for childcare. Evidently, the economic incentives for ESs can be used to supply modern energy such as Liquid Petrolium Gas (LPG) and electricity at an affordable cost, technology development and interventions for sustainable resource use value addition in NTFPs, agroecosystems redevelopment and agrobiodiversity conservation, and reduction in human drudgery. The present subsidy of firewood (in practice people collect firewood from even reserved forests, if community forests are unable to meet their demands) could be replaced by the subsidy on LPG or other modern energy sources to enable communities to conserve their forests.

According to a study carried out by Balland *et. al.* (2006) in some villages of Uttarakhand and Himachal Pradesh that a cooking gas subsidy to the tune of Rs. 200 per LPG cylinder is estimated to reduce firewood demand by 44%, and induce the proportion of households using LPG rise from 7% to 78%. The subsidy will cost approximately Rs. 120,000 annually per village. When firewood is thus replaced, the Carbon sink and other ESs are strengthened. A 0.5% increase in efficiency of India's automobile fleet is likely to free-up nearly sufficient fuel energy for cooking needs of the poor in the entire Himalaya (Singh, 2007). Rather than excluding such a subsidy of LPG, some of the nature's one time gift ought to be actually conserved to fulfill our obligation to bring the health and welfare of all people to a reasonable level, and to enhance the ESs providing capacity of the Himalayan forests.

The information presented above on forest ESs of the Uttarakhand are only rough estimates, and need to be taken as the first approximations. However, they are good enough to establish that the ESs from the state are contributing to human welfare in our country. In case we fail to give adequate weight to them in our accounting and other valuing systems, sustainable human welfare may be drastically affected. Seeing the huge value of ESs it would be impractical to think that they would be incorporated *per se* into national accounting systems. However, decision makers can initiate steps to better reflect the values of ESs and natural capital in centre-to-state transfer of funds. There is a need to “greening the budget” and giving full value to the services of forests at the national level (Singh, 2003). Even a crude estimation of goods drawn from forests would indicate that they contribute far more than 1% to the national economy (Singh, 2003). By compensating for ESs in monitory terms, the decision makers would contribute to brining about a major qualitative change in the conservation approach.

With the growing consumptive traits, the country with its huge population is soon going to be a major CO_2 emitter among the countries of the world, even if per capita emissions were low. Since as per our economic policy, we are not going to slow down the increasing per capita CO_2 emission, we need to promote the health of our sinks. In a tropical country like India with high mean temperatures even a limited warming can exceed the tolerance limits of organisms, including humans and ecosystems in which they live. In Uttarakhand, community forestry has been strongly institutionalized, and issues of ESs can directly affect their economic condition and processes leading to the empowerment of local people. Recognition of ESs in national policies may enable the local people to own Carbon trade and other ecological enterprises, and hence to play a far greater role in conservation activities. At present policies do not provide adequate incentives to the states that maintain large areas under forests and instead some times create problems to secure development opportunities.

The National Environment Policy recognizes it, that unless the conservation measures address the question of livelihood security of people, they will not be successful. The financial support for the Himalayan states in general and Uttarakhand in particular would essentially be used to (i) maintain the flow of ESs to the rest of the country on a sustainable basis, and (ii) therefore, improve the quality of life without jeopardising the national ecological security. We need to reinvigorate our policy and institutional framework that addresses the questions of sustainable development in view of emerging challenges. In this regard, a robust framework of payment for ecological services to the communities concerned is imperative and needs to be put in place without any further delay. We need to set up an empowered groups at the state and national level to deal with this question within their respective jurisdictions.

It is evident from some of the successful examples on ecosystem valuation world wide the funds transfer cannot only be limited from the central government to the state. Individuals and organizations that receive benefits from a particular ecosystem need to contribute for its protection and restoration. However, before this, there is a major need to generate substantial scientific knowledge and spread awareness on the value of various ESs. Though this may require longer-term studies by multidisciplinary teams yet available knowledge may be utilized to generate willingness to pay among the beneficiaries according to their ability to contribute. As a state, Uttarakhand is well placed in meeting the challenges of policy, institutional and technical interventions required for valuation of ESs. High degree of literacy; traditional and cultural awareness on the values of forests; existence of many forest, wildlife, and environment related institutions of national and international repute; low population and compact nature of the state are important assets to set the ball rolling in Uttarakhand. This new approach, if developed successfully, offers hope to conserve natural resources on one hand and socio-economic development of local communities on the other. However, based on the experiences that are emerging from different parts of the globe, Government's role as a supporter, regulator, and facilitator is indispensable to achieve the desired results.

Chapter 2

Forests Ecosystem Services

The amount of available secondary information led us to categorize the studied forest ecosystem services into two groups: the major forest ESs such as Carbon Sequestration, Non Timber Forest Products, Agrobiodiversity, Hydrological Regulations, Recreation and Pollination that have been described in this chapter whereas some other ESs have been briefly presented under chapter 4 as Other Forest Ecosystem Services of Uttarakhand.

2.1 Carbon Sequestration by Uttarakhand Forests: A tangible Ecosystem Service

Carbon sequestration is the process by which atmospheric Carbon dioxide (CO_2) is absorbed by trees through photosynthesis and stored as Carbon in plant biomass (boles, branches, leaves, and roots) and in soils. Carbon sequestration is among the most important ESs provided by forested regions and the most talked about in the wake of minimizing human induced impacts on changing global climate.

Climate change induced by increased greenhouse gases (GHGs) emissions is real and has begun to touch us. Human activities have increased CO_2 concentration from 280 to 372 ppm in less than two centuries and global temperature by 0.6 °C in the past century (Folland *et. al.,* 2001). Carbon sequestration helps offset the Carbon addition to the atmosphere through fossil fuel emissions. The valuation of this ESs is difficult but possible to calculate. Already, excessive destruction of forests and the large scale use of fossil fuels in the post industrial revolution period have led to a rise in CO_2 and other GHGs levels in the atmosphere and weakened the buffering capacity of natural ecosystems. While less advertised than impacts in coastal areas where sea level rise directly threatens coastal communities, the impact in Himalaya is no less severe. In addition to anecdotal evidence which would seem to indicate more accentuated weather events (such as cloud bursts), the impact of accelerated glacial melting in the Himalaya is likely to lead to severe water shortages as the flow of snow fed rivers will first increase due to rapid melting of glaciers and will subsequently decline due to reduction in the size of glaciers.


Robust trees in forests sequester a large amount of Carbon

An example of a catastrophic event not usually connected to global warming would be the devastating flood of August 1st, 2000 that swept away 200 people in Kinnaur and Shimla districts of Himachal Pradesh. Initially attributed to cloud bursts, Indian Space Research Organisation scientists later revealed the cause to be the bursting of a glacial lake on the Pareechu river. Such an incident is unlikely to be isolated. Using global climate data, the Washington based Worldwatch Institute had long warned that the river originating in the Himalaya is expected to swell abnormally (Sharma, 2005). Worldwatch Institute also reports that the average retreat of Gangotri is now 30 m yr^{-1}, compared with 18 m yr^{-1} between 1935 and 1990, and 7 m yr^{-1} between 1842 and 1935. This is a four-fold increase in the speed of glacial retreat in about a century. Basing its argument on the fact that the Himalayan glaciers were rapidly melting, the report had also warned about the sudden bursting of glacial lakes and flash floods in entire northern India.

Gaumukh glacier is receding faster than ever before due to global warming

Sustainable forestry practices can increase the ability of forests to sequester atmospheric CO_2 while at the same time enhance other ESs, such as improved soil and water quality. Carbon sequestration is also a good indicator of the health and functioning of ecosystems. While Carbon sequestration may not be the most important of ESs provided by the Himalayan forests, it is among the easiest to value given the current active trading scenario. In addition to commitments made by Governments through various treaties, the voluntary "retail" market for Carbon is growing as more and more individuals and entities seek to purchase Carbon offsets to reduce their emission footprint or become "Carbon neutral". Voluntary markets play a significant role in climate change mitigation. By allowing broader public to engage in climate protection, the voluntary markets advance societal awareness climate change and the impacts of consumer behaviour on environment. The ability to trade Carbon credits makes Carbon sequestration among the most widely discussed and studied ecosystem service. While current price of Carbon are in the order of US$ 10-20 **t**$^{-1}$, these vary greatly and prices are prone to market fluctuation. Rates ranging from US$ 2 to US$ 28 **t**$^{-1}$ can be found in various different regions.

Carbon Stock and Sequestration Rates in Forests of Uttarakhand

Due to high forest cover, the Himalayan forests are large reservoirs of Carbon. Majority of the forests of Uttarakhand can be broadly divided into six types: sub tropical forest (sal), dry deciduous forests, moist deciduous forests, tropical coniferous forests (pine), temperate broad leaved, and temperate coniferous forests.

Biomass values of forest stands in the Himalaya tend to cluster around two very different levels- from a low approximately 200 **t** ha^{-1} for early successional communities such as chir pine, to a high of about 400 **t** ha^{-1} for late successional communities such as the oaks and sal (Singh and Singh, 1992). Tree biomass in excess of 700 **t** ha^{-1} has been reported for old growth sal in the Himalayan foothills as well as mixed oak forests at mid-altitudes which is higher than biomass values reported for many tropical rainforests. In addition old growth forests have high levels of soil Carbon making, late successional Himalayan forests very valuable in terms of Carbon storage potential.

Carbon storage in the Uttarakhand Himalayan forests ranges from an average of about 175 **t** C ha^{-1} for chir pine forests to approx 300 **t** C ha^{-1} for oak and sal dominated forests (Singh, 1987) though higher values are not unusual.

In terms of Carbon credits alone Carbon sequestered by a mature oak forest would be worth over US$ 8,000 ha^{-1}. While Carbon from mature forests cannot be sold in the Carbon trade market presently operating under the Kyoto Protocol, this is an indicative value of the worth of such forests. Such valuations thus help provide an economic basis to protect mature oak or sal forests without the need to build other arguments such as forest biodiversity and aesthetic values to be passed on to future generations.

Total Carbon Sequestration Value of the Forests of Uttarakhand

The forests of Uttarakhand can accumulate Carbon at rate that ranges from 5-9 **t** C ha^{-1} yr^{-1} for good forests to 1.5 - 3 **t** C ha^{-1} yr^{-1} for poor quality forests (Singh, *et. al.,* 1985). This translates to Carbon sequestration values of almost US $ 65 - US $ 125 ha^{-1} yr^{-1} for good forests @ of US $ 13 **t** C ha^{-1}. These values are not dissimilar from the profitability from growing cereals or millets in terraced fields. Thus, if Carbon credit trading values remain stable or moderately increase (as is predicted), the economic worth from forest protection should rival the profitability from terraced agricultural fields. These figures do not even put a worth on the increase in biodiversity, groundwater recharge, climate moderation and other beneficial impacts of forests or increase in tourism potential which can add real economic value.

Table 2.1.1 represents the values of C-sequestration in the various forest types in Uttarakhand. The values in different forest types vary between US$ 2.21 million and US$. 29.77 million. The total value of C-sequestration @ of US$ 13 in the international market by forest of Uttarakhand would be US$ 85.93 million yr^{-1}.

Table 2.1.1: Carbon in Different Forest Ecosystem Types of Uttarakhand.

(Forest area based on remote sensed data by P.S. Roy and P. Joshi (unpublished). Carbon values were based on Rana *et. al.* (1989) and Singh and Singh (1992), in which biomass and productivity were determined by actually harvesting trees and Carbon by measuring concentration in each component. These values were estimated both for aboveground and belowground components. The estimates based on six undisturbed forest stands of all major types along an altitudinal gradient of over 2000 m were adjusted for disturbed conditions in the region by multiplying with a correction of 0.63 derived from Singh and Singh (1992).The total Carbon sequestration value has been estimated at the rate of US$ 13 t^{-1} C; Source: Singh *et. al.* (2004).

Forest Type	Area (km^2)	Biomass (M t C)	Net Accumulation in biomass (M t C yr^{-1})	Soil (150 cm depth) (M t C)	Value of Carbon sequestration (million US $)
Temperate Conifer Forest	6017.06	37.15	1.59	68.54	20.67
Temperate Broad Leaved Forest	7808.81	119.30	2.29	111.95	29.77
Tropical Coniferous (Pine) Forest	5418.03	33.45	1.43	61.71	18.59
Moist Deciduous Forest	3027.25	54.45	0.92	15.10	11.96
Dry Deciduous Forest	695.31	12.51	0.21	3.47	2.73
Sub Tropical (Sal) Forest	561.59	10.10	0.17	2.80	2.21
Total	**23528.05**	**266.96**	**6.61**	**263.58**	**85.93**

Soil Carbon Pool

Most of the data on forest soil Carbon of Uttarakhand Himalaya are based on top 30 cm soil depth, which may account for only a small fraction of soil Carbon. On an average the percentage of Carbon in the top 20 cm, relative to that in the first meter soil column is 50% and the amount in the next 2 meters is 56% of that in the first meter. Thus, the forest soils are expected to contain about three times as much soil Carbon as compared to the reported values on the basis of top 30 cm soil. Carbon content in the surface layer of soil is mostly affected by climate, whereas clay content seems to regulate deeper soil Carbon (Jabbagy and Jackson, 2000). The turnover of the deep soil Carbon is slow which could be important from the standpoint of Carbon sequestration. There is a need to understand vertical Carbon distribution in soils of different kinds of forest ecosystems.

In a study carried out by Tewari and Jina, (unpublished) in a banj oak (*Quercus leucotrichophora*) and chir pine (*Pinus roxburghii*) forests of Uttarakhand that are under community management regime, the deeper soil layers 60-150 cm have two times more soil Carbon than the top layers. Even at 150 cm depth the soil Carbon is as high as 1% and the projected Carbon in the forest soils of Uttarakhand up to 150m depth is 263.58 million t. Its value would be worth US $ 3426.54 million @ of US $ 13 t^{-1} in the international market (Table 2.1.1).

Carbon Sequestration in Community Forests

Uttarakhand occupies a special place in the participatory management of common forest resources because of its Van Panchayats (VPs), representing one of the oldest participatory forest management institutions in the world. Data on C-sequestration collected from the 3 VPs in Uttarakhand over a three year period indicate that the C-sequestration rate varies between 2 **t** ha^{-1} yr^{-1} and 4 **t** ha^{-1} yr^{-1} depending on the condition of the forest (Table 2.1.2). Taking a mean sequestration rate of 3 **t** ha^{-1} yr^{-1} and total forest area under community management 523,289 ha, the community forests sequester 1.4 million **t** C yr^{-1}. The value of the Carbon saved is about Rs 18.2 million @ US $ 13 $\mathbf{t}^{-1}$ C yr^{-1}.

Table 2.1.2: Variations in Carbon stock in different forest types of studied VPs and their mean C-Sequestration rates. (Yr_1=Year 1, Yr_2=Year 2, Yr_3=Year 3)

Forest types	Carbon mass (t ha^{-1})			Mean C Sequestration rate (t C ha^{-1} yr^{-1})
	Yr_1 (t ha^{-1})	Yr_2 (t ha^{-1})	Yr_3 (t ha^{-1})	
Mixed oak forest	148.9	152.5	155.4	3.6
Chir pine mixed forest	95.1	99.2	103.0	4.1
Pure Chir forest	69.5	74.0	78.4	4.4

Carbon Trade and Forest Ecosystem Restoration in Uttarakhand

Carbon has become a commodity which can be traded at national and international levels with no cost of transportation and quality control. C-credits are already operational in some parts of the world and Netherlands has taken a lead in this area. Forests of Uttarakhand have a Carbon stock of 266.96 million **t** according to a rough estimate. There are serious threats to this C-stock if conservation measures were not positively linked to economic growth. The poor people in Uttarakhand depend heavily on firewood as a source of cooking energy. Fuel wood consumption per capita in the 1500-2000m zone in the Garhwal region is approx. 2 kg day^{-1} (Bhatt and Sachan, 2004). It varies from 2.8 kg at higher altitudes (>2000m) to 1.42 kg $capita^{-1}$ day^{-1} at lower altitudes (1000-1500m) and lower still in the foot hills. Assuming on a simple calculation a dependence of about 3 million people living in the hills on fuel wood, and an average consumption of 1.7 kg $capita^{-1}$ day^{-1}, this translates into almost 2 million **t** of fuel wood $year^{-1}$ for the Uttarakhand Himalaya or about 1.0 million **t** Carbon. It is not possible to conserve forests for long without enabling the poor people to have access to modern, efficient energy sources such as LPG, biogas solar energy and electricity (modern energy sources, hereby referred to as MES). There is a need to replace the present subsidy of firewood by providing MES. For example, a small 1 cubic meter biogas plant can save 15 kg of fuel wood per day. This would translate into a direct savings of 2 **t** Carbon annually, or over an eight year period (a conservative estimate for the life of a biogas plant) 16 **t** of Carbon and worth US$ 250-300 would be saved. This is more than the cost of construction of a biogas plant. The Van Panchayats can contribute for these MES which may be provided at subsidised rates by sale of C-sequestered annually in their forests. Additionally, the ecosystem would benefit indirectly through much higher productivity (and hence higher Carbon sequestration) as the process of lopping for fuel wood damages buds, leaves and greatly reduces the photosynthetic potential of a tree. Similarly, any subsidy given on a fodder programme to replace tree fodder with grasses would pay for itself in a very short time in terms of increased Carbon sequestration rates of forests. The major hindrance has been that Clean Development Mechanism (CDM) under Kyoto Protocol which does not recognize Carbon credits that are in a sense 'created' by preventing forest degradation (Box 2.1.1). There are no rewards for protecting a forest.

For Carbon credits, the focus must be on avoiding deforestation/forest degradation along with afforestation and reforestation of degraded forest ecosystems. For example, mature oak forests in Uttarakhand or Nepal generally contain up to 330 **t** C ha^{-1} in their vegetation (Rana *et. al.,* 1989). A new plantation may take 100-300 years to accumulate the pre-logging stocks of Carbon.

Carbon Market Opportunities

The term Carbon market refers to the buying and selling of emissions permits that have been either distributed by a regulatory body or generated by Green House Gases (GHGs) emission reduction projects. GHG emission reduction is traded as Carbon credits, which represents the reduction of GHGs equal to one metric ton of CO_2 - the most common GHG. Carbon markets can be separated into two major categories: the compliance (or regulatory) regulated under United Nation Framework Convention on Climate Change (UNFCCC) and voluntary markets. Even before the Kyoto Protocol, Carbon transactions were occurring through such markets. During the 1990s the retail and voluntary markets grew slowly but certain key developments started emerging. Companies whose entire business focused on Carbon market were born, including prominent like Eco securities and Future forests. While the overall Carbon market shuddered for two or three years after the withdrawal of the United State of America (USA)from the Kyoto Protocol, the retail and voluntary markets continued to diversify. The Chicago Climate Exchange was established in 2003 as the first voluntary Carbon credit market. The size of this market range from 2 million **t** Carbon to 20 million **t**, including a whole range of voluntary offsets, retail offsets, green power programme etc.

The market is still developing, but recent worldwide initiatives suggest that forestry offsets could play an important role in achieving the emission reduction targets agreed by signatories to the Kyoto Protocol. In addition to the market regulated by UNFCCC, several other developing private markets aim to regulate their environmental impacts, such as emissions of GHGs. Many companies in the USA and Canada are involved in the trade of Carbon credits with the ultimate aim of developing a workable market mechanism for Carbon.

Box 2.1.1: Carbon Sequestration and Kyoto Protocol

As per some formal economic models, the overall costs and risks of climate change will be to losing at least 5% of global GDP annually. However, the costs of minimizing GHGs (primarily CO_2) emissions to avoid the most negative impacts can be limited to around 1% of global GDP each year. Therefore Carbon sequestration has been receiving considerable attention in recent years as a result of its commoditization - Carbon credits are now traded in international markets. Kyoto Protocol was signed in Japan in December 1998 and enforced from 16 February, 2005. The Protocol states that the industrialised countries will reduce their collective GHGs emission by 5% compared to the 1990 level. The goal is to reduce overall emissions of GHGs over the five year period between 2008 and 2012. Following are the ways to achieve this (i) enhancement of the energy efficiency in relevant sectors of the national economy (ii) protection and enhancement of sinks not controlled by the Montreal Protocol, 1987 (iii) promotion of sustainable forms of agriculture in the light of climate change considerations (iv) research on development and increased use of renewable and non renewable forms of energy of CO_2 sequestration technologies (v) progressive phasing out of market imperfection, tax and duty exemptions and subsidies in all GHGs emitting sectors and promotion of policies and measures which limit or reduce emissions (vi) limitation and reduction of methane emissions through recovery and use in waste management and transport and distribution of energy (Source: MoEF). Even without the Kyoto Protocol in force, trade in Carbon was worth approximately US$ 300 million in 2002. This figure includes payment for both C-sinks and C-reduction emissions through technology inputs (Salzman, 2005 and Report of the Task Force on Mountain Ecosystems, 2006). While the forests of Uttarakhand hold significant amount of Carbon, some region today have become net source of carbon due to forest loss and degradation. Carbon sequestration can be used to provide additional revenues that make various agroforestry practices significantly more profitable than before.

Conclusion/Recommendations

Carbon has become a new form of global commodity in the wake of minimizing human induced impacts on global warming. This is being traded in regulated and voluntary markets across the world. Though Carbon sequestered in biomass and forest and agriculture soils can be estimated accurately, information on Carbon sequestration rates in soils is extremely limited in Uttarakhand. At present the national and international mechanisms though appreciate the role of afforestation and reforestation in climate change mitigation yet the Carbon stock in existing forests has been over looked. The Van Panchayats of Uttarakhand are playing a vital role in forest protection have to be rewarded through appropriate payment mechanisms to make them more effective and efficient.

2.2. Value of Non-Timber Forest Products in Uttarakhand

Non-Timber Forest Products (NTFPs) is an umbrella term used for a vast array of goods of biological origin other than timber derived from the forests. However, considering many conservation, cultural and ethical issues related to wild animals and their derivatives, these have been excluded from being considered as NTFPs. These are a wealth of useful goods with significant potential to ensure livelihood security at community level.

Based on origin, NTFPs may be arranged broadly in four classes viz., plant fruits, seeds, and nuts; plant exudes-latex, resin, and nectar; plant parts-stem, leaf, root, bark, apical buds, flowers, mushrooms, and orchids; and non plant products such as lac and silk.

Commonly collected NTFPs in the Himalaya include a variety of medicinal and aromatic plants (MAPs), pine resin, lichens, moss, wild mushrooms, berries, and honey. The value of NTFPs in poverty alleviation of marginalised forest-dependent communities has for long been acknowledged. The focus of interest is now on whether sustainable harvest from wild, cultivation on private farmland and commercialisation of NTFPs can support local people to achieve sustainable livelihoods in changed socio-economic scenario.

NTFPs and Livelihoods

The past decade has witnessed a rapid growth of interest in NTFPs among conservation and development organizations, in part at least due to the recognition of the contribution that these make to the livelihoods of a large number of people in developing countries. Research has focused on exploring the contribution that NTFPs can make to sustainable development by increasing financial income to rural communities and by increasing the value of forest resources, thereby providing an incentive for conservation. As a result, commercialization of NTFPs is widely considered to offer a mechanism by which conservation and development goals can be achieved concurrently. Some recent studies do point out pitfalls of this development strategy. The sale of NTFPs often tends to provide a basic level of income for the poorest section of communities, rather than providing a method of socio-economic advancement. The level of cash income received by those involved in collection is often very low; in some situations, dependency on income from sale of NTFPs may apparently perpetuate poverty rather than alleviate it. Similarly, several reviews of the ecological impacts of commercial harvesting have concluded that many of these resources are harvested destructively, or on an unsustainable basis.

Across the Indian Himalaya, there is very little data available on the quantum of harvesting of NTFPs from the forests. What little is available tends to be sketchy and conflicting and does not lend itself to credible analysis. Current harvest levels, sustainable harvest levels or means to encourage the propagation of economically valuable NTFPs is by-in-large poorly understood.

In most areas, NTFP harvesting is a taboo subject, as the collection of most MAPs as well as several other economically important NTFPs has been declared illegal. While its collection does exist on a significant scale, there are few estimates available on the quantities or value of products being traded. Studies are needed to assess the potential and sustainability of this trade. Villagers for fear of being reported to the authorities naturally withhold what they consider to be sensitive and potentially incriminating information. It would appear that the commercial marketing of MAPs has been around for many centuries.

Historical Context

Since 1921, when commercial exploitation of MAPs in this region first began through auctions, collectors have been subjected to various government prescribed procedures and guidelines. In 1950, the Department of Cooperation (DOC) was awarded marketing rights. In 1962, this system was replaced by private contractors who paid a fixed amount in royalties. These contractors were appointed by the Forest Department. This system was scrapped after the complaints about exploitation of collectors and non remunerative wages, and the DOC system returned in 1979. In the mid 1980s, the Medicinal Plants and Herbs Development Project (MPHDP) was initiated which entailed the establishment of grassroots level local cooperatives with a paid government employee from the Horticulture Department as secretary, affiliated to district level organizations called Bhesaj Sanghs (Medicinal Plants Cooperative Unions).

Current Status

In Uttarakhand and much of the Himalaya, the most profitable NTFPs are endangered and threatened medicinal plants whose extraction has been banned after India became a signatory to the CITES convention on trafficking in endangered species of plants and animals. Hence, for many of these NTFPs there exist significant legal issues if any kind of collection is to be permitted. Yet, illegal extraction continues on a large scale with both local collectors and migrant labour (hired by traders) involved in this activity depending on the products and region.

While much of the rural community is classified as agriculturists, the traditional lifestyle of the people living in Uttarakhand, like that of most highland communities across the world, had distinctive characteristics and cannot be as easily compartmentalized. Traditionally, the rural economy has consisted of a basket of activities, in which agriculture and animal husbandry provide the base to the subsistence economy. Trading across borders, handicrafts, and extraction and processing of NTFPs, provided the base for the market economy.

Essential to the survival of the agro pastoral-economy, which is still the mainstay of the majority of the rural people, is the dependence on forests for all elements of life, *e.g.,* firewood, fodder, fiber, medicines, supplementary foods, water, and soil conservation and fertility maintenance. Leaf fodder for cattle, and leaf litter for cattle bedding provide energy and nutrient inputs that sustain agriculture in Uttarakhand.

Biomass products such as fuel wood, fodder and leaf litter while neglected in almost all accounting systems need to be recognized as the most valuable NTFPs being extracted from the forests and a basis of the current rural economy of Uttarakhand. These biomass products are however often treated in a category of their own and for the purposes of the discussion below are not being included as NTFPs.

Institutions Relevant to NTFP Management in Uttarakhand

a. State Forest Department (SFD)

The SFD is responsible for production and sustenance of NTFPs. However, it does not trade in NTFPs with the exception of resin. It mainly acts as a regulator in the total process of procurement and collection. It allots coups to registered agencies, such as Uttarakhand Forest Development Corporation (UFDC), Bhesaj Sanghs, Garhwal Mandal Vikas Nigam (GMVN) and Kumaun Mandal Vikas Nigam (KMVN) for procurement and collection of NTFPs and charges royalty on such collection.

Resin is procured and traded by the forest department through the three main depots in the state to different units inside and out side the state. At present the trade process of the NTFPs other than resin is controlled by UFDC.

b. Uttarakhand Forest Development Corporation (UFDC)

This functions as a corporate body and is involved in the scientific management of forest resources. Until recently, it primarily dealt with the trade of the timber and minor minerals from the forest area. Since 2004, it has also taken the responsibility of trade of MAPs.

c. Herbal Research and Development Institute (HRDI)

Set up as a research and development agency, HRDI has a good field establishment in Chamoli district of the state. The HRDI is helping in certification of farmers for MAP cultivation and training and developing of package of practices. The recent inclusion of the Bhesaj Sanghs as a partner to HRDI further strengthens the ability of this organization to deliver results in this sector.

d. Bhesaj Sanghs (Medicinal Plants Cooperative Unions)

Bhesaj Sangh is a cooperative mechanism for the regulation of medicinal plants collection and their trade in the state. They are district level collectors cooperatives, which were set up under the Horticulture Department. Bhesaj Sanghs were mandated with training on medicinal plants cultivation for growers. However, the functioning of the Bhesaj Sanghs is not very professional and the politicization of this body has been a major hindrance. Recently, there has been an attempt to professionalise this body through improving coordination and expertise provided through the HRDI.

In theory, under the Bhesaj Sanghs, members of village-based cooperative societies were to be trained in sustainable harvesting / collection techniques and then issued with licenses at the start of collection season for rights to harvest specific species that are not under the endangered or threatened categories.

Thus, there was an excellent institutional mechanism in place which was supposed to assist in minimizing exploitation of local collectors by middle-men while at the same time conserving endangered MAPs. However, the profit earned by the Bhesaj Sangh is low and it is estimated that a small fraction, well under 5%, of the total trade in NTFPs occurs through these institutions. Typically, once a 'member' obtains a license to harvest MAPs from the Sangh, it acts as a contractor, hiring a group of cheap migrant labour to do the actual MAP collection totally unsupervised. Some time not only harvesting is carried out unsustainably, but in order to increase profitability a range of MAPs many of them endangered are collected and sold to private traders.

e. Other Research Institutions

G.B. Pant Institute of Himalayan Environment and Development (GBPIHED) an autonomous institute of Ministry of Environment and Forests, High Altitude Plant Physiology Research Centre (HAPPRC) of Garhwal University, Srinagar, and various NGOs are involved in research and development programme on medicinal plant conservation and cultivation. These organizations are also engaged in capacity building of local communities and extension activities.

Cultivation and Collection Practices

It is heartening to know that some of the traditional farmers inhabiting the buffer zone of Nanda Devi Biosphere Reserve have successfully domesticated a number of medicinal plants including *Angelica glauca, Carum carvi, Megacarpea polyandra, Pleurospermum angelicoides*, *Saussurea costus and Allium* spp. etc., at small scale (Maikhuri *et. al.,* 1998).

A recent study carried out in the Munsiari area of district Pithoragarh, Kumaun, by a student of the Indian Institute of Rural Management (IRMA), found that of 32 MAP collectors interviewed, all were selling their produce to private traders. These private traders not only offer higher prices than the Bhesaj Sanghs but even more importantly, many of them offer much-needed credit facilities, assured buybacks, and act as money lenders for collectors. Government programmes pay little attention to this huge problem of rural credit.

NTFPs collection is, however, remains exploitative for the local collectors. A study on lichen collection was carried out by Appropriate Technology India (ATI), Ukhimath, revealed that while the collectors receive only 34.5% of the price paid by the final buyers, the rest went to the middle men wholesellers and others in the marketing chain. Studies have also found that in some cases the collectors appear to receive a higher proportion of the final selling price, but in many of these cases adulteration is done in the collected products by the intermediate traders.

Despite the importance, the proper management of NTFPs has been neglected in the state. Forest management has traditionally been timber oriented. Changing paradigms in the last few decades increased the focus on preservation of resources rather than attempting to generate livelihoods. The declaration of Uttarakhand as a 'Herbal State' in 2003 did bring some attention to Medicinal Plant cultivation, but little was done to improve collection of NTFPs or to address issues related to people whose livelihoods are greatly impacted by its collection. Many observers have argued that even if NTFPs were still widely available, their importance as a source of livelihood earning has declined because of the changes in lifestyle and work ethic of the rural population. The collection is hard, physically demanding work, fraught with dangers of not only injury but also getting caught by forest guards. In a survey carried out by Jain and Nagarwala (2006) in Chamoli and Rudraprayag districts shows that NTFPs did not contribute more than 6% of the total income of any village surveyed. However, it was observed that people were quite cautious while speaking about the collection of MAPs from the forests due to the fear of the forest officials and hence earnings were often under reported.

There exists a fairly significant market for NTFPs. In areas above 2000m altitude, or in villages with access to high altitude pastures, a very significant proportion of the population, roughly over 30% households depend on NTFPs gathering for a substantive part of their earnings.

Important NTFPs of Uttarakhand

In terms of value and volume, the important among NTFPs such as fodder, fuel wood and leaf litter are not even typically mentioned when NTFPs are discussed. Thus, only few viz., resin, lichen, moss and MAPs are important from the revenue earning point of view.




Some prominent NTFPs viz., stone flower, sphagnum moss , resin, medicinal plant-Kuth

Recognised NTFPs can be divided into two groups those that are primarily traded through official channels and records of which are available with the state forest department (SFD) and those that are traded unofficially. While resin would be a good example of the former category, some of MAPs are largely traded illegally. A brief discussion of some important NTFPs is given below:

- **Resin from Chir Pine (*Pinus roxburghii*)**

Resin is an important NTFP and the genus *Pinus* is best known as a source of this product. In Uttarakhand, resin is collected almost exclusively from *Pinus roxburghii* trees.

Resin collection is controlled and managed by the SFD. In areas dominated by *P. roxburghii* it is an important activity and contributes significant revenue as well as employment opportunities in Uttarakhand. In 2005-06, revenue generated from resin production in the state was Rs. 453 million (Source: Uttarakhand Forest Statistics 2005-06).

Collection and Procurement: Resin is collected from the forest according to working plans made by the SFD. The SFD employs registered labour for tapping and collection of resin. Till 1996, resin was collected largely by cup and leap method, which damaged the trees. Thereafter, the rill method is used which not only has much lower impact on trees but also increases resin production. Resin is collected and transported,in tin canisters, to jungle head and then road head depots. From here it is transported to the following three main head depots in the state:

- Rishikesh, Narendranagar Forest Division
- Sultannagri, Kathgodam, Nainital Forest Division
- Tanakpur, Champawat Forest Division

Processing: Processing is done by the units after resin is sold by the SFD. Resin is processed by simple distillation method to form two main products namely rosin and turpentine oil used in varnish, paints and polishes, paper manufacturing etc.

- **Lichen and Mosses**

In terms of volume, lichens and mosses are the most common NTFPs that are collected from the state. While biologically very different, these two NTFPs are often grouped together due to their similarity of appearance.

Lichens or ***Jhula***, are symbiotic associations of algae and fungi. They are most abundant in temperate forests at altitudes from about 1500m and above. Often associated with oaks and rhododendrons, they are also commonly found on apple and other fruit trees. Lichens of the genus *Parmelia* are most commonly collected. In Ukhimath range (Rudraprayag district), over the past 8 years approx. 17.0 **t** of lichens were removed annually. This however would appear to be an under-estimate and reflects only Government records. Independent estimates from the region put the actual collection at closer to 200.0-250.0 **t** per year. As per estimates made by forest officials in Chamoli district, between July and March about 60-75 trucks of lichens are collected every year. Given an average of about 3.0 **t** per truck this would translate to about 180-200 **t** annually. Further a price of about Rs. 25 per kg to the collectors translates to a value of Rs. 4,500,000 - 5,000,000 from the district. However, mandi prices are Rs. 55-60 which translate to a value of Rs. 10 million for Chamoli district alone.

While the collection of lichens *per se* is not destructive to trees, due to the relatively low profitability and use of outside contract labour, the harvesting is done without any concern for the trees, and branches are indiscriminately lopped off rather than scraping off the lichens from the branches. This causes severe damage to the trees. While there is considerable unrecorded trade, a significant proportion of the lichens harvested is sold through official channels as described below:

Collection / Procurement

The SFD allots land to UFDC, Kumaun Mandal Vikas Nigam and Bhesaj Sanghs for lichen collection. The registered collectors of these agencies, often assisted by local or migrant labour, collect and pack the produce in sacks. The field officer of the UFDC inspects the material and takes a permit from the concerned Range Officer of the SFD and after the verification, it is brought it to the above mentioned three main depots for sale.

Big traders purchase Jhula in bulk. A small amount is also bought by the local pharmacies within the state. After processing and gradation, dealers sell lichens in bulk amount to spice and ayurvedic manufacturers (such as Himalaya Drugs, Dabur, Jhandu) and to small traders.

Products: The products made out of Jhula are: Spices, Ayurvedic Medicines, Organic Dye and *Hawan Samgri.*

Market: The market for Jhula is spread all over the country but has special demand in Gujarat, Mumbai and South India. A large part of the lichens collected in the Himalaya goes to a place called 'Nander' in Gujarat where there is a hub of spice manufacturers. In the North India lichens are mainly used in Ayurvedic medicines and as *Hawan Samgri*. The traders also sell it in the Khari Bawli market in Delhi.

Mosses : Mosses are easier to collect and used largely by florists and garden shops for moss-sticks. While lower in value than lichens and collected in smaller amounts, the market is nonetheless worth several hundred thousand rupees. Among mosses genus *Sphagnum* is collected most commonly. It is abundantly found in oak forests and grows well in cool, humid areas. Its main use is in plant nurseries where it is used as a medium of propagation by cutting and air layering. It is said to have a fungicidal effect and thus helps in protecting newly emerging seedlings and roots. It is used in making moss sticks, which gives support to trailing vine type ornamental plants. It can soak moisture 8 to 10 times its weight and thus is used to support indoor basket plants. It is also used as a base of small plants that have to be transported over long distances as it retains moisture for longer period of time.

Collection and trade is carried out in a manner similar to lichens and these two NTFPs are often grouped together in policy matters. Traders purchase it from Government operated *mandis* and then sell it to nurseries etc. At present the sale rate from the depot is Rs. 25 to Rs. 27 according to the quality of the product. The price of the Moss after processing and cleaning ranges from Rs. 35 to Rs. 50 per kg. At present the collectors pay royalty of 50 paisa per kg to the SFD.

- **Bamboo Resource**

In Uttarakhand some of the marginal communities such *Ruriya* and also other traditional communities inhabiting higher altitude areas of the state are dependent on bamboo resources for part of their livelihoods. The most common bamboos of the state are Ringal *(Arundinaria falcata)* and Tham abundantly occurring in temperate and sub alpine forests. Local craftsmen make a variety of household items such as baskets and mats from this resource. Ringal and

Making household utensils and handicraft items from local bamboo is a livelihood earning activity of some traditional communities

Tham bamboos are also used as a thatch material for covering roofs. Of late, local craftsmen have started making a number of fancy handicraft items from Ringal bamboo which are sold to a large number of tourists and pilgrims visiting the state.

Establishment of the Uttarakhand Bamboo and Fibre Development Board (UBFDB) a few years ago has greatly increased the focus on bamboo planting and handicrafts made from bamboos. Bamboo planting has been included in forest working plans and several thousand hectares of bamboo have already been planted across the state. Training of bamboo artisans and products such as the 'Badrinath pooja basket' which has been used by thousands of pilgrims has greatly increased the value of this NTFP.

- **Medicinal and Aromatic Plants**

Any discussion on NTFPs from the Himalaya would almost certainly focus on this very important group of plants for which the Himalaya is best known. While many of the important MAPs are herbs or small shrubs, a good example of a perennial form would be the Yew tree (*Taxus baccata*) which gained great attention due to the anti-carcenogenic properties of taxol mainly found in its bark (Box 2.2.1).

Box 2.2.1: Himalayan Yew: *Taxus baccata*

T. baccata L. is one of the high value medicinal plants of Uttarakhand. The anti-cancer drug Taxol (paclitaxel; a diterpenoid) is isolated from the stem bark. Extracts of *T. baccata* is also known to be source of a drug called "*Zarnab*", which is prescribed in the Unani system of Indian medicine (CSIR, 1976) and used as sedative and for the treatment of bronchitis, asthama, epilepsy, snake bites and scorpion stings, besides applications as an aphrodisiac (Beckstrom-Sternberg and Duke, 1993). The use of its bark as a substitute (or mixed with) tea is also known. Taxol is currently used in the treatment of several forms of breast, liver, lung, blood and gynaecological cancers. Average taxol content in the bark of yew trees across an age series was found to range between 0.064 and 8.032 g/tree, and a tree of about 100 yrs age can yield about 5.74 kg dry bark (Nadeem *et. al.,* 2002).

This tree occurs between 1800 and 3300 m amsl in central Himalaya, the other tree associates being *Cedrus deodara, Abies pindrow, Aesculs indica, R. arboreum, Lyonia ovalifolia, Quercus floribunda,* etc. (Nandi *et. al.*, 1998). Due to its medicinal importance large-scale exploitation has been continuing until recently from this region. Consumption of seeds along with aril (a sweet, fleshy cup like structure surrounding the seed) by birds, monkeys and humans causes regeneration failure to this tree. Efforts for conservation and mass multiplication of this species using growth *hormones* are being made by GBPIHED.

Some of the most important MAPs include:

Keera-Jari a unique and high value NTFP occurs in high altitude areas

Kira-jari (*Cordyceps sinensis*)

Also known as Yarchagumba kira-jari is a rare species of parasitic fungus that grows on the bodies/head of insect larvae (*Hepialis virescens*) (Please refer Box 2.2.2).

Box 2.2.2. Kira-Jari Collection: ANSAB's Experiences from Nepal indicate that it takes 5 persons about a month to collect 3500-4000 pieces of kira-jari which weigh about 1 kg. Locals involved in collection said that the skill of the collector was very important and an unskilled collector would not even be able to collect 10 g in a month while a proficient collector might collect over a kg in less than a month. Prices of about Rs. 120,000 to 150,000 per kg were quoted by collectors. While the quantum of collection is unknown, estimates of over 800-1000 kg are not uncommon from Uttarakhand which would have an approximate value of over Rs. 100 million. It is mostly used in Chinese system of medicine.

Jatamansi (*Nardostachys spp.)*

Found between about 3400-4000m, the roots of jatamansi are highly prized as incense. Local use of Jatamansi in India is estimated at 300 **t**. These figures put a value of approximately Rs. 75 million to Rs. 250 million for the country on Jatamansi trade alone.

Kutki (*Picrorhiza kurrooa*)

Found between 3200 and 4500m, the roots of Kutki are used to treat abdominal pains and fevers. It is being cultivated at lower altitudes through support provided by HRDI. Locals in Joshimath (Chamoli) estimated that approx 10-12 tons of Kutki were harvested from the forests. At a cost of Rs. 180 per kg, this would put the value of Kutki harvested from the area at about Rs.2,000,000. In Uttarakhand, India, the High Altitude Plant Physiology Research Centre's efforts to promote the cultivation of *Picrorhiza kurrooa*, a high value medicinal plant, differ significantly from similar attempts by other agencies. Farmers are given not only technical but comprehensive support, including assistance in marketing. Taking a farming system's approach, the Centre provides planting material and training to farmers. More importantly, it has arranged a buying contract with a commercial company that commits to purchase the complete production of kutki at a guaranteed minimum price. This has been made possible through a tripartite agreement between the farmers, the company, and the Centre.

Hatha Jari / Salam-panja (*Dactylorhiza hatagirea*)

A high altitude member of the orchid family, this important NTFP is typically found in marshy meadows and along stream at altitudes of 3000-4500m. Due to over harvesting, this species is said to have declined fairly dramatically in the last decade. The tuberous roots are valuable in ayurvedic medicines.

Atees (*Aconitum heterophyllum*)

A relatively rare and endangered NTFP that has suffered as a result of unsustainable extraction, the tubers of this species are used for the treatment of fever, rheumatism and stomach ache. Local people use this plant and store the dry roots as an emergency medicine.

Jambu / Faran (*Allium humile* and other Allium spp)

A popular aromatic culinary herb, this is another high altitude NTFP typically found above 3500m. The leaves and stem are harvested, chopped into small pieces and used to season vegetables. The plant sells at Rs. 200-300 per kg. Harvest as per some estimates is about 25 t in Uttarakhand which would put a value of around Rs. 600,000 on this NTFP.

Gandrayan/Choru (*Angelica glauca*)

A perennial herb found at altitudes of 2700-300m, it has fleshy roots which are aromatic and used as a condiment as well as for stomach disorders and as a purgative.

- **Mushrooms and Wild Edible Fruits**

Several edible mushrooms are found in Uttarakhand including some very tasty *Agaricus* species. Locals typically do not harvest most species due to lack of awareness to distinguish between edible and poisonous species. An easy to identify and very valuable mushroom is the Himalayan morel.

***Himalayan morel mushroom* (*Morchella esculenta*)**

The Himalayan morel mushroom, locally known as guchii is found at altitudes from 1,800 m to over 3,000 m. In Nepal this mushroom was collected for domestic use and as a delicious vegetable. In Uttarakhand its collection has become common largely after its economic value became known to local people (Box 2.2.3).

Box 2.2.3. *Morchella esculenta*: A high value NTFP of higher Himalayan Forests

This edible mushroom was found growing naturally in the humus rich forest floors of broadleaf-mixed conifer forests in Uttarakhand. The fruiting body (scientifically called ascocarp) appears on soil surface soon after rains during March-April. People set surface fire every year during winter and believe that such a practice improves *Morchella* yield. The ascocarps are collected during May-June are cooked with rice and vegetables and considered nutritious. The decoction of ascocarp after boiling with water is used in medicine and health care system by the local communities. Out of the five species of *Morchella* found in India, *M. esculenta* is expensive because of its rich nutritional value coupled with a unique falvour.

In the Niti valley of Chamoli district approx. 40 villages inhabited by about 1600 families mostly involved in the collection of *Morchella* during summer. On average, a person may collect 2-3 kg freshly weighing *Morchella* per day. The ascocarps are then hanged under roofs of the houses for 15-20 days for air drying. Every season a family (3-5 persons) collect an average 1.5 kg air dry weight of *Morchella* that is sold by the local middleman @ Rs. 5000 kg^{-1}. It has been realized that though the local people earn good amount of money from this wild resource, its indiscriminate extraction and traditional practice of setting fire on forest floor leads many-fold negative impacts on forest biodiversity and ecosystem services and calls for more studies to find out an environment friendly techniques to harvest this useful product of nature (Prasad *et.al.,* 2002).

Wild Fruits

Several forest trees and shrubs bear fruits that are consumed locally and some times even marketed. Fruits such as Kaphal (*Myrica esculenta*) while valued and consumed locally, rarely made it to the market in the past can now be increasingly seen in markets during early summers (Box 2.2.4). Similarly squash is prepared from *Rhododendron arboreum* flowers and sold in local market (Box 2.2.5). Some of the important wild fruits found in (1000-2000m amsl) of Uttarakhand include:

Kaphal (*Myrica*) stony berries rich in vitamin C

- Hisalu *(Rubus ellipticus),* Kingore (*Berberis asiatica*) and related shrubs with tasty berries
- Wild apricots (Chyuli or Chuaru) (Prunus)
- Mehal or wild pear (*Pyrus pashia*)

Other important fruit include the wild bel (*Aegle marmelos)*, Pangar or wild chestnut (*Aesculus indica)* Himalayan Amla (*Emblica Officinalis), Ficus roxburghii* (Wild Himalayan fig).

Box 2.2.4: *Myrica esculenta* (Kafal)- A wild understorey tree of multiple value

M. esculenta Buch.-Ham. (locally know as Kafal) is a small or moderate sized evergreen tree occurs in pine, oak and mixed oak forests of middle altitudes of Uttarakhand. The genus *Myrica* is one of the non-leguminous angiosperm nodulated by Frankia spp and hence capable of fixing atmospheric nitrogen like legumes. This tree yields delicious fruits during May-June and eaten raw by the local people.

Kafal (*Myrica esculenta*) an important succulent wild fruit collected and sold by rural people to augment their income

It is the much cherished wild fruit of the region and particularly attracts children and women while they frequent the forests for daily needs of fodder and fuel wood. In the Kumaun region Kafal fruit is sold in local markets during summer for the last more than two decades. A detailed study conducted by Dhyani & Dhar (1992) reported that a number of villagers in Almora district are involved in collecting the raw fruits, which are sold directly and also through the middle-men in the near by urban centres. They reported the yield of fruits ranging from 30-111 kg/tree and on average, a person collected and sold about 20 kg fruits per day (@ Rs. 12-20 /kg) and about 567 kg fruit/month thus earning about Rs. 8364/season). Another study conducted by Bhatt *et. al.* (2000) reported that local people in Kumaun region can earn over Rs. 1.4 million /season from selling this fruits. They recorded the maximum fruit yield in Chir pine forest (42.1 kg/tree) and minimum in mixed oak forest (28.9 kg/tree) and the potential yield as 2-4.3 t ha^{-1} of forest area. Of the total fruit crop only 2.87% was harvested across different forest sites. In some sampled villages, as many as 60% of the total households were involved in collection/sale of these fruits. Observations during 2007 revealed that the rates touched as high as Rs. 80-100/kg (Amar Ujala, May 2007). However, the same day in the evening the rates dropped by Rs. 20-40/kg, as the fruit is perishable and its flavour deteriorates rapidly. Also, in the recent years the fruit selling trade has still grown up and Kafal fruits are sold in bulk by the local women to the traders early morning at some locally fixed trading centres in the townships of Almora and Ranikhet, and immediately transported to Haldwani where they are sold at a much higher rate.

This multipurpose tree (Key stone species.) due to its virtues has also found place in the Uttrakhand's folklore. This tree is also considered a good quality fuel wood and also used as fodder occasionally. Due to immense pressure on the already sparsely distributed Kafal trees in the forests of this region their regeneration in Garhwal hills has been found poor (Badola,1993). G.B. Pant Institute of Himalayan Environment and Development is working on various biotechnological methods including air layering to overcome the problem of low natural regeneration of *M. esculenta* (Purohit *et. al.,* 2005).

The seeds of the wild apricot yield good quantities of oil that finds use in cosmetics. Already some NGOs in Uttarakhand are successfully facilitating marketing this oil.

Sea-buckthorns are deciduous shrubs of the genus *Hippophae* commonly known as Leh Berry in India. It is used in

traditional medicines and the berries are a rich source of vitamins. It widely occurs in higher altitude valleys along stream banks in Uttarakhand and locally known as Ames.

Box 2.2.5: Rhododendrons form a major plant group in temperate zone having a characteristic slow growth rate and ornamental value. Rhododendrons are common associate of oak and pine forests and sub-alpine vegetation in Uttarakhand. Rhododendron is one of the largest genera of family ericaceae, having ecological significance and economic importance in addition to its graceful flowers (Paul *et. al.,* 2005). Among the five species of rhododendrons (viz., *R. arboreum, R. campanulatum, R.barbatum, R. anthopogon, R. lepidotum*) that occur in Uttarakhand, *R. arboreum* is the State Tree of Uttarakhand. It has aesthetic, sacred, aromatic, medicinal and fuel wood values. Of late native people have started exploiting the flowers of *R. arboreum* (Burans) for extraction of juice and squash preparation.

Rhododendron (Burans) flowers enhance the scenic beauty of forest landscapes. The petals are used for making squash

The magnificent flowers bloom during January-March. Due to human interference, natural populations of rhododendrons are gradually diminishing in the entire Himalaya. Rhododendrons which are classified as rare, endangered and threatened may be wiped out in near future from the biota, if proper management and conservation initiatives are not taken up urgently. The squash made out of the rhododendron flowers is sold in many hill towns now in Uttarakhand @ Rs. 100/litre. The squash is considered to be beneficial in ailments such as high blood pressure and heart ailments. "*Burans ka Juice*" is becoming popular in the region and some people keep this in their home and feel proud offering it to the old friends and visitors. As far as the juice/squash extraction and selling in the local towns is considered, Burans juice is much compared to other less preferred such as bel, apricot, etc.

● Honey

In the Himalaya, much of the honey production is dependent on the pollen of wild trees, bees are very important pollinator of cultivated crops. A decline in the yield of fruit trees in many parts of the Himalaya has been linked with depleted honey bee populations.

The principle species of bee which are kept in hives and managed for honey production and crop pollination are *Apis cerana* and *Apis mellifera*. *Apis cerana,* the native honey bee is not popular among commercial beekeepers in the Himalaya because of its low honey yield and undesirable behavioral traits such as frequent swarming and absconding.

Apis florea, Apis dorsata, and *Apis laboriosa* are wild species of the honey bee and cannot be kept in hives. These species build single comb nests on tall trees and cliffs.

Apis melifera, the European bee was introduced to the region to promote beekeeping as a commercial enterprise and it has a high honey yield and a hive can yield 30-50 kg of honey per year. However, it is susceptible to disease and low temperatures and cannot easily be maintained in the mountains unless beekeepers move the boxes down to lower altitudes during winter. Nonetheless, it is very popular with commercial beekeepers, which largely replace *Apis cerana,* the ecological implications of which are still not known.

In Uttarakhand wall-hives with colonies of *Apis cerana* have been traditionally nurtured. The practice had declined somewhat for several reasons, such as a change in construction material (from stone walls to brick walls) that make wall hives more difficult to keep and maintain, and also because of declining bee populations attributed to indiscriminate use of pesticides in fruit growing areas. However, bee-rearing is seeing a small resurgence in the region. A few NGOs and enterprenuers have aggressive programmes aimed at increasing bee colonies and the yield of honey per colony.

Honey yields can be increased from about 2-3 kg per hive annually to 5-7 kg per hive through use of better technologies such as removable combs. In newer wall hives frames are often inserted which allow for non-destructive removal of the hive and harvesting of honey rather than the old practice of cutting the hive out of the wall which resulted in its destruction and necessitated that bees build a fresh comb which in turn reduced honey yield.

There are no accurate estimates of honey production in Uttarakhand. Appropriate Technology India (ATI), ivolved in large scale hony trade, sells approximately 70 t annually much of it collected from Rudraprayag and Chamoli districts. Much of the honey in the district is consumed locally or sold directly to tourists, as the prices for direct sale (Rs. 100-150 per litre) is typically much higher than prices when sold to institutions that brand and further market the honey (Rs. 30-70 per litre). The price of certified organic honey is however significantly higher and can significantly increase farmer incomes. Overall, Himalayan honey can fetch higher prices than honey produced in the plains because a buyer is likely to pay a premium for honey produced in what is considered to be a relatively pristine and pure environment.

- **Tassar Silk**

A niche activity is the production of tassar and other non-mulberry silks through use of leaves harvested from the forest. *Quercus semecarpifolia* has been most commonly used. Eri and muga silks have also been produced in Uttarakhand in limited quantities using species such as *Litsea* and Castor (*Ricinus*). However, the scope in terms of using forest resources vis-a-vis productivety needs to be assessed for promotion of Tassar Silk in the state.

Conclusions/Recommendations

NTFPs conservation and community based enterprises development can help promote sustainable resource use and improve the livelihoods of marginal local communities in Uttarakhand.

The sector in the state is afflicted by a number of issues that inhibit local communities from adequately benefiting from its rich forest resources. In Uttarakhand lack of awareness, capacities and clearly defined property rights and poverty are leading to over exploitation to a host of NTFPs for short term benefits. In addition increasing market demand led extraction is threatening the existence of many species in the wild and at the same time marginal poor communities are often exploited by middlemen traders who dominate the some times secretive, largely unorganised, yet with strong network trade. As most high-value high altitude NTFPs including medicinal plants are sold in raw form without local value addition, the local gatherers receive only a small share considering the value of the final products. Despite the large growth of the sector in recent years, the policy linking livelihoods of local communities with forest resources is not adequately developed to address this issue effectively.

So far comprehensive scientific initiatives are lacking on the ecological impacts of NTFP harvesting on forest ecosystems and also to develop conservation friendly community based enterprises. Whatever little is known indicates that capacity building of local institutions such as Van Panchayats and Panchayati Raj Institutions and supportive policies may provide sustained economic benefits form MTFP sector to local people and promote conservation of natural resources. A limited number of community-based enterprises that exist are also facing the typical second-generation problems in sustaining these efforts particularly in the absence of proper monitoring of NTFPs based enterprises and lack of policy support to link the local enterprises with mainstream markets, establishing rural credit scheme and assured buy backs. The sector has the potential to provide a unique opportunity whose potential is still remain to be harnessed fully for improving livelihoods of local communities. In addition, large scale replications of a successful natural product based enterprises may also contribute to the national conservation goals.

2.3 Agrobiodiversity Value of Uttarakhand

Biodiversity is part of natural capital, and the flow of ecosystem services on which humans depend can be considered as the interest on that capital. It depends on human societies how they invest in the capital (biodiversity) to maximize sustained flow of the interest i.e. ecosystem services. Rich biodiversity in agroecosystems holds the key to respond to environmental risks including possible climate change. While the conservation paradigms across the globe are always concerned about loss of biodiversity in natural ecosystems, species extinction in human managed agroecosystems often escaped attention. However, dwindling agrobiodiversity in traditional agriculture also has an opportunity cost. The loss has implications not only for household food and nutritional security but also for a variety of ecosystem services (Perrings *et. al.,* 2006).

Agriculture expansion is still one of the greatest factors responsible for forest conversion and related biodiversity loss in the world. The situation seems paradoxical when the decisions have to be taken on what is to be conserved-the domesticated biodiversity or the wild one. For human sustenance both are indispensable and therefore, one type of biodiversity can not be conserved at the expense of other type. In fact inference can be drawn from available scientific literature that rich biodiversity in both natural and human managed ecosystems is complementary and hence may enhance chances of its survival in both types of ecosystems. Ecological science has yet to address the trade-offs between food production, biodiversity conservation, ecosystem services, and societal well being in human dominated landscapes. Perrings *et. al.,* 2006 proposed three assumptions on the importance of biodiversity: (1) that a vast majority of species are still not utilized fully holding promise that research may discover their new uses not just for medicine, but also for food and other household goods, and rich diversity of crop plants is not a threat to agriculture; it is the key to its sustainability; (2) the monoculture and over utilization of just a few species in agriculture require inputs like chemical fertilizers, and application of pesticides which may affect non-target species and pollute environment, and (3) non recognition of the wider role of agrobiodiversity in agroecosystems means that inadequate attention has been paid to the risks associated with the loss of important ecosystem services.

There is no denying of the fact that intensive modern agriculture, at least in the short run, solved the problem of hunger to an extent, yet the environmental and socio-economic problems associated with it are gradually becoming apparent. Intensive agriculture relies on use of High Yielding Varieties (HYVs) of crops, chemical fertilizers, pesticides, and fossil fuels. This is not only responsible for the loss of diversity of breeds, farm birds, beneficial insects, and soil biota in agroecosystems but agricultural intensification also puts wild biodiversity at risk through gene flow from domesticated varieties to wild species, cross-species transmission of potentially virulent pathogens, and adverse effects of fertilizers and pesticides on non target species in adjacent natural ecosystems (Perrings *et. al.,* 2006). Consequently, it disturbs the flow of a large number of ecosystem services (Box 2.3.1).

Box 2.3.1 Until a unique cooperation among farmers, researchers and extension worker in China, experimental information was lacking to support observations and theories that indicate maintaining genetic heterogeneity in crop fields helps protect monocultured crops from disease and pest attack. In China, field experiments were carried out to test these theories and observations. Genetically heterogeneous rice crops were planted in all the rice fields in five townships in 1998, and 10 townships in 1999. Impacts of diversity on the control of rice blast disease were compared with monoculture crops. It was observed that when the disease-susceptible rice varieties were planted in mixtures with resistant varieties, the yield was 89% greater and blast severity was 94% less than when they were grown as monoculture. At the end of the two year programme, application of fungicides was not required to protect the crop from blast. The experiment supported the hypothesis that maintaining intra and inter-specific crop diversity could be an ecological approach to control disease and pest attack in crop plants. The approach can be highly effective over a large area and contribute to the sustainability of crop production. Thus, mixed cropping produced more total grain per ha than when these are grown as monocultures in all cases. In addition it has been estimated that monoculture required more land (1.18 ha) to produce the amount what mixed cropping could provide in 1 ha. The total value per ha of the mixture was 14% greater than monocultures and in some cases even 40% greater than monoculture. (Adapted from Zhu *et. al.,* 2000. Nature, 406 (17): 718-722).

It is evident from the growing literature such as Alterie (1995), Ramakrishanan, (1992) and Maikhuri *et. al.* (1997, 2001) and as also described in the Box 2.3.1, maintaining agrobiodiversity in farming systems is crucial for sustainable livelihoods and flow of ecosystem services. However, the scientific understanding is still limited to develop sound conservation strategy. The loss of agrobiodiversity in traditional agriculture is the result of change in various socio-economic factors and exiting policy and institutional arrangements that consider agriculture as a mere production system rather than an ecological system. To cite few examples, the traditional crops without sufficient scientific information about them are considered inferior than the HYVs and as a result growing and consumption of these crops is also considered as a sign of social backwardness; markets provide farmers little incentive to conserve traditional crops; and international biodiversity conservation efforts are mainly concentrated in the biodiversity hotspots and ecoregions and pay almost no attention to agrobiodiversity conservation now increasingly being recognized as a precious component of biodiversity.

At times even mixed cropping is unable to protect amaranth plants from pest attack in some areas of Uttarakhand

The international concern to protect biodiversity in agricultural landscapes has also been highlighted at the 1992

United Nations Conference on Environment and Development (UNCED). This produced the Convention on Biological Diversity (CBD), an intergovernmental convention ratified by 176 countries came into force in 1993 and subsequently Decision II/15 of the Conference of Parties (COP) to the CBD identified the unique nature of agricultural biodiversity and Decision III/11 in 1996 established a programme of work on Agricultural Biodiversity. The situation is changing in some parts of the world as evident from the recent reforms of Europe's Common Agricultural Policy and also in India the promulgation of Biodiversity Conservation Act 2002. In Uttarakhand scientific information being generated by GBPIHED since 1991, existence of Universities and scientific institutions especially devoted to work on agricultural development, voluntary organization like Beej Bachao Andolan (Save the Seeds Campaign), and formation of Uttarakhand Organic Board are some positive signs that give hope for the conservation of a huge diversity of traditional crops in the mountainous parts of the state.

This young state can take pride in the fact that approximately 14% of its geographical area is under PA network, indicating the rich biodiversity that occur along altitudinal gradient ranging from 300 m amsl in the south to perpetually snow clad mountains over 6000 m amsl in the north. On the other hand, local farmers maintain a staggering diversity of crop plants across different agro-climatic zones of the state providing ecosystem service (biodiversity) of both local and global importance. A flight of agricultural terraces in the matrix of forests with a variety of colorful traditional crops such as amaranth provide yet other ecosystem services in terms of scenic beauty to the mountainous landscapes, and perhaps also playing a role in hydrological regulation. Thus, these could be considered farmers' assisted ecosystem services having local, regional, national and global value.

Agriculture Landscape of Uttarakhand

In the mountainous parts of the state covering approx. 89% (47326 km^2) of the total geographical area, agriculture remains the core economic activity for over 80% of population (Semwal and Maikhuri, 1996). Agriculture, forest, and animal husbandry are the interlinked production systems in this region and role of forests and traditional agroforestry in sustaining the agriculture and animal husbandry systems is immense. The three basic farming systems viz., settled agriculture practiced by a vast majority of traditional farmers; transhumance by small Bhotiya community; and nomadism by even smaller Van Gujjars, are all dependent on surrounding forests for various resources (Singh *et. al.,* 1984; Semwal *et. al.,* 2001). Settled agriculture, a mixed crop livestock farming system is practiced by nearly five million local farmers inhabiting the mountainous part of the state covering approximatly 6000 km^2 as net sown area. In the past, along the warm river valleys of the Garhwal; slash and burn agriculture locally called as *Katil, or Kureel* was a large scale practice (Pauw, 1886). However, now this practice is restricted to a few localities only (Nautiyal *et. al.,* 1998).

Terraced agricultural field in the matrix of forests are the focus of economic activities in Uttarakhand

The traditional settled agriculture of Uttarakhand exhibits a great deal of heterogeneity in crop diversity as over 40 different crop species and hundreds of their local cultivars are grown and maintained through a variety of crop composition and crop rotations along altitudinal transact due to great variations in physiographic, ecological and social of factors. As such, the region can be divided into three markedly different agro-climatic zones along the elevational gradient viz., lower altitude, 500-1000 m; middle altitude between 1000 and 1800 m, and higher altitude, 1800 and 2500 m and above. Settled agricultural land use in mountainous parts is, by and large, rainfed and only little over 10% land is irrigated and intensively cultivated to grow rice, wheat and mustard. In some locations in irrigated land of lower altitude valleys a third crop of hog millet (*Panicum miliacium*) locally known as bhangana is also grown between April and July, albeit on a smaller scale. Owing to cold climatic conditions in higher altitude >2000m, most of the crops are cultivated during summer-rainy season between March and October.

In the rainfed agriculture (along 500-2500 m altitudinal gradient), the hotspot of agrobiodiversity, cropping patterns are built around two seasons, the Kharif (summer) and the Rabi (winter). In a normal traditional setting, rainfed agricultural land of a village is divided into two halves called '*Sars'*. A *Sar* is fallowed during one winter cropping seasons over a period of two years. Thus, half of the village rainfed agricultural land remains as fallow during winter seasons (Nautiyal *et. al.,* 1998; Semwal *et. al.,* 2001). In some high altitude areas and under slash and burn agriculture *katil,* the fallow period may extend from three to six years before the land is brought under cultivation again, the practice locally known as *tesali*. There are some practices which are traditionally followed by all households, e.g., (1) finger millet and paddy are grown in alternate years in a given field, (2) finger millet is almost always mixed with pulses, (3) threshing of amaranth and buckwheat is done in the farm itself and all crop residues are recycled back whereas, in the case of others, aboveground portion is taken away from fields and residues are fed to livestock meeting 30-35% of the annual fodder demand of local households and recycled in agriculture through farmyard manure (FYM) (Rao *et. al.,* 2005).

Mostly there are marginal farmers (>70%) in the mountainous parts of Uttarakhand whose land holdings usually range between 0.02 and 1.0 ha while the remaining are generally small land holders possessing 1.0 to 4.0 ha of agricultural land. Per capita landholding in the hills is about 0.11 ha. It is interesting to note that as opposed to general perception, the population pressure on per ha of cultivated land is higher (8.6 persons) in Uttarakhand than in most densely populated Gangetic Plains (2-3 persons). With in Uttarakhand, across the altitudinal gradient, the per capita land holding is often higher at higher altitude than middle and lower altitudes. Therefore, as far as the economic condition of the farmers of different agro-climatic zones is concerned; higher altitude farmers are generally economically better off than their lower and middle altitude counterparts. The major reasons apart from bigger landholdings are: low population, greater accessibility to forest resources and more importantly suitable niche for cultivation of some crops such as potato, amaranth, buck wheat, kidney bean and also for high value medicinal plants which have great market demands now these days. The agriculture of lower altitudes apart from other factors suffers the influences of modern farming practices not necessarily suitable and migration of young people which is more pronounced here.

Agrobiodiversity Scenario

Traditional agriculture of the Uttarakhand is the repository of agrobiodiversity. Over 40 different crops and hundreds of farmers selected cultivars comprising cereals, millets, pseudo-cereals, pulses and tuber are cultivated along altitudinal gradient in Uttarakhand (Table 2.3.1).

Table: 2. 3. 1 Agricultural crop diversity across an altitudinal gradient in Uttarakhand (Source: Maikhuri *et. al.* 1997)

Crop species	Common name	Local name	Attitudinal range (meters above means sea level)
Allium cepa	Onion	Pyaz	500–1100
Allium humile		Jimbu/Faran	2500–3000
Amaranthus oleracea	Amaranth	Chaulai	500–2500
A. *frumentaceus*	Amaranth	Chuwa/Marcha /Ramdana	1500–2500
Avena sativa	Oat	Jai	2000–2500
Brassica compestris	Mustard	Sarson	500–2200
Brassica spp	Mustard	Toriya	500–2000
Cajanus cajan	Pigeon pea	Tor	500–1800
Canabis sativa	Hemp	Bhang	1500–2500
Carum Carvi		Kala Jeera	2200–3000
Chenopodium album	Pig-weed	Bhetu	2000–2500
Cleome viscosa		Jakhiya	500–1500
Colocasia himalayensis	Taro	Pindalu/Kuchain	500–1500
Echinochloa frumentacea	Barnyard millet	Jhangora	500–1800
Eleusine coracana	Finger millet	Koda	500–2000
Fagopyrum esculentum	Buck wheat	Oggal	1900–2500
Fagopyrum tataricum	Buck wheat	Phaphar	1900–2500
Glycine soja	Soyabean	Bhatt	800–1800
Glysine spp	Soyabean	Kala Bhatt	1000–1800
Glycine max	Soyabean	Soyabean	500–1400
Hibiscus. subdarifa	Roselle	Sun	500–1500
Hordeum himalayens	Nacked barley	O-wa-jau	1400–2300
Hordeum vulgare	Barley	Jau	500–2000
Lens esculenta	Lentil	Masoor	500–2000
Macrotyloma unit/orum	Horsegram	Gahat	500–1800
Oryza sativa	Paddy	Satti	500–1800
O sativa	Paddy	Dhan	500–1500
Panicum miliaceum	Hog-millet	Cheena/Bhangna	500–2000
Perilla frutescense	Perilla	Bhangjeera	1000–1800
Phaseolus vulgaris	Kidney bean	Razma	1500–2500
Pisum sativum	Pea	Matar	500–1500
Pisum spp		Kong	1000–1900
Pleurospermum angelicoides		Choru	2200–3000
Sausurea costus		Kut	2200–3000
Sesamum indicum	Sesame	Til	1500–2500
Setaria italica	Foxtail millet	Kauni	500–1500
Solanum tuberosum	Potato	Alu	1000–2500
Sorghum vulgare	Pearl millet	Junyali	1000–1800
Triticum aestivum	Wheat	Gehun	500–2500
Vigna aconitifolia	Mat bean	Bhringa	800–1600
V. angularis	Adjuki bean	Rains	900–2200
V. mungo	Black gram	Urad	500–1800
V. radiata	Green gram	Mung	500–1000
V. unguiculata	Cow pea	Sonta	500–1800
V. umbel/ata	Rice bean	Bhotiya	1200–2200
Zea mays	Maize	Mungri	500–1800
Zingiber officina/e	Zinger	Adrak	500–1200

Paddy, wheat, finger millet, amaranth, barnyard millet, mustard, buck wheat, black gram, kidney bean, pigeon pea and potato are some of important crops of the region. This rich diversity of crop plants is maintained by deriving huge amount of nutrients from forest ecosystems and through a variety of crop composition and rotations in time and space by local marginal farmers. These crops are adapted in the local environmental condition and possess the inherent qualities to withstand the environmental risk and other natural hazards. This adaptability has, in fact, protected the hill farmers from absolute crop failure since millennia (Box-2.3.2).

Box 2.3.2: Baranaja System

In Garhwal region of Uttarakhand traditional farmers still maintain mixed cropping of a number of traditional food crops under rainfed agriculture during Kharif season albeit only in some isolated pockets in present times. *Baranaja* literally meaning a cropping pattern where 12 different cereals and millets are cultivated simultaneously as a mixed crop following sequential sowing and harvesting. However, in the local parlance *baranaja* also means a huge variety of food crops grown during entire Kharif season in a village farm land. In actual practice, though a large number of food crops including cereals, millets, pseudo cereals, pulses, condiments, and few vegetables are cultivated together, the number of crops often vary depending upon the agro-climatic conditions and social setup of a concerned village or a village cluster. Generally the mixture of crops grown in such agricultural practice is selected among the following crops viz., rice, finger millet, barnyard millet, foxtail millet, buckwheat, amaranth, black gram, local black soyabean, horse gram, rice bean, cow pea, foxtail millet, kidney bean, cleome, roselle and some times few of the vegetables. In the past, when the regional subsistence economy was self sustaining, the practice of *baranaja* catered to the diverse nutraceutical needs of households, provided insurance against absolute crop failure due to pest attack or other natural hazards, higher productivity per unit area under marginal land holding situation and also to capitalize upon the environmental heterogeneity. Though the practice of *baranaja* has undergone many changes in the recent times and at some locations not maintained any more in the wake of policies and institutions promoting modern agricultural practices and changed socio-economic scenario, the renewed interest in traditional agriculture across the globe including in India may help revive and redevelop this practice in near future.

Mixed cropping of cereals, millets and pulses is a common practice which helps in maintaining high crop diversity

Many of these crops also contain medicinal properties and used by the local people to cure different diseases (Maikhuri *et. al.,* 1991, 1997, 2001). In lower and middle altitudes farmers traditionally maintain a number of multipurpose tree (MPTs) species (*Grewia optiva, Boehmeria rugulosa, Ficus roxburghii, F. glomerata, Celtis australis,* and *Bauhinia variegata* etc.) on the raised margin of their private agricultural terraces enhancing the diversity in the agroecosystems. The density of these MPTs may vary from few trees to some times more than 400 trees ha^{-1} in different locations in the state (Nautiyal *et.al,.* 1998). The MPTs provide green fodder and a range of other products to the villagers near their dwellings year round particularly during lean periods (Maikhuri *et. al.,* 2000; Negi, *et. al.,* 2002) (Table-2.3.2).

Many multipurpose tree species are maintained traditionally by local farmers on the raised margins of their rainfed terraces

Table 2.3.2: Some Important Characteristics of Multipurpose Trees Suitable for Wasteland Restoration in Uttarakhand (Source: Negi *et. al.*, 2002).

Species	Main use	Leaf drop season	Crude Protein content (%)	Season of major use
Bauhinia variegata(D)	FD, FR	Summer	18.1	Winter
Boehmeria rugulosa (E)	FD	Summer		Winter
Celtis australis (D)	FD, FR	Autumn	8.2	Summer
Ficus roburghii (SE)	FD	summer		Winter
Grewia optiva(SE)	FD, FR	Summer	26.1	Winter
Melia azedarach(D)	MT, FR	Winter	18.4	Rainy
Prunus cerasoides (SE)	SC, S	Autumn	19.2	Year-round
Quercus leucotrichophora(E)	FD, FR, SC	Summer	18.1	Year-round
Albizia stipulata(D)	FR	Winter	15	Summer
Alnus nepalensis (D)	SC	Winter	12.6	Year-round
Dalbergia sissoo(D)	T	Winter	9.1	Summer
Ougeinia dalbergioides (D)	FD, AG	Spring	18.2	Summer

FD= fodder, FR = firewood, MT = minor timber, SC = Soil & water conservation, S = sacred, T = timber, AG = agricultural implements, F = fiber, M = medicine, D = deciduous, SE = semi evergreen, E = evergreen (Source: Negi, G.C.S. & Varun Joshi, 2001. Agroforestry trees restore degraded land in the Himalayas. Agroforestry Today 13 (1-2): 19-21.)

As mentioned, all the three types of farming systems are forest dependent and livestock based. Over four million livestock comprising buffaloes, cows, goats, sheep, yaks, horses, and mules apart from playing a crucial role in the subsistence economy and transforming wild vegetation base into dung and Farmyard Manure, the huge range of genetic diversity with in this component further enhances the agrobiodiversity of the traditional agroecosystems in the state. High agrobiodiversity of the region is not only important locally for household food and nutritional security but can also be considered as farmers' assisted ecosystem service of global value. However, the state is loosing this precious resource due to a variety of factors related to environment, policy and institutional backing that no longer remain necessarily supportive in the changed socio-economic milieu. The agriculture operations are extremely drudgery driven. No technological solutions have been suggested to minimize human drudgery or for that matter upgrade quality of inputs such as farm yard manure contributing > 50% of the total inputs in agriculture in energy terms. Generally partly decomposed FYM consisting of forest leaf litter (used as animal bedding) mixed with livestock dung, urine, and feed left over is applied, which does add humus to the soil but little soil nutrients. Weeding alone particularly during Kharif (summer-rainy) season absorbs > 40% of human energy (Semwal and Maikhuri, 1996). In the present times, when the regional economy is fast merging with mainstream economy, maintaining large number of crop species for household food security has lost relevance, as it can be secured through market. The area under a number of traditional crops has drastically come down (> 60%) particularly during last three decades due to lack of policy and limited institutional support to farmers for maintaining biodiversity rich agroecosystems. Many of the crops are at the brink of extinction such as *Panicum miliaceum, Glysine sp, Setaria italica, Hibiscus sabdarifa, Vigna spp.* and *Perrila fruitiscence* to name a few (BOX 2.3.3). At the moment it is difficult to elaborate that how much genetic resource and knowledge about traditional crops has already been lost. Efforts have to be made to conserve all surviving crop species for the biodiversity benefits such agroecosystems provide, not only to local communities but to human societies across the globe (Maikhuri *et. al*., 1997, 2001).

Some lesser known traditional crops of Uttarakhand.

Box 2.3.3: In Uttarakhand Himalaya where the traditional agriculture is sustained with forest resources, land-use change has significant implications for sustainable livelihood of local communities. A study conducted by Semwal *et al.* (2004) in a micro watershed in Garhwal Himalaya reveals that over three decades (19631993), agricultural land use increased by 30% at the expense of loss of 5% of forestland. Agricultural expansion was greatest (60 %) in community forests compared to 35% in protected forests, and 5% in reserve forests. Owing to suitable niche for cash crop cultivation such as potato, at higher altitude (1800-2600 m) and on medium slopes, agricultural expansion was observed to be most obvious in the watershed. In the process, during above period, cultivation of buckwheat (*Fagopyrum esculentum, Fagopyrum tataricum*, hogmillet (*Panicum miliaceum*) and foxtail millet (*Setaria italica)* was abandoned. Potato (*Solanum tuberosum*), completely replaced the area under the abandoned traditional crops. Soil loss (See table below), run-off and manure input related to potato cultivation was much higher compared to traditional crops.

***Soil loss from different crop fields and terraced slopes in the Pranmati watershed of Central Himalaya (based on Sen et. al., 1997 and Rao et. al., 2005*).**

Crop	Soil loss from terraced slopes (t ha^{-1} $year^{-1}$)					
	Low ($<2^0$)		Medium ($2-6^0$)		High ($6-10^0$)	
	1993	1994	1993	1994	1993	1994
Finger Millet	0.658	0.089	1.199	0.386	6.037	0.525
Amaranth	0.517	0.372	1.462	0.437	13.435	1.475
Barnyard Millet	0.536	0.093	1.213	0.310	7.578	0.652
Rice	0.300	0.334	2.950	0.429	8.122	1.050
Potato	0.060	0.327	7.653	1.812	64.400	3.758

(*Microtyloma uniflorum*), emphasis on cultivation of those crops having some arket demand, and introduction of new crops having similar value has also been reported by Negi and Joshi, 2002 from Dugargad watershed located in mid agro-climatic zone of Garhwal Himalya. Though these changes have enhanced household income but at the cost forest degradation and loss of forest cover. Sustained diminution of forest resources will result in lower economic returns from agriculture to local people together with loss of global benefits from wild and agrobiodiversity related ecosystem services. Policy support for sustainable income from forests to local people as well as technologies enhancing agricultural productivity through conservation of traditional crop diversity is needed for livelihood of local people. This support may also help maintain the forest ecosystem services recognized as global benefits flowing from the forested landscapes of Uttarakhand.

There is limited scope for local communities to derive direct economic benefits from forests under present policy framework. However, policy does permit unregulated use of forest resources in terms of fodder, fuel wood, and leaf litter needed for preparing traditional compost. The above study shows that in the recent past, in certain areas of Uttarakhand, agricultural expansion and management practices have changed in a manner that have increased the intensity of grazing, lopping, and litter removal in forests, and soil loss and run-off from agroecosystems and also responsible for erosion crop diversity. Scientific interventions for improvement in soil and nutrient conservation, economic incentives for maintaining agrobiodiversity, and forest policies supporting income generation from sustainable utilization of NTFPs for local communities may minimize the chances of decline in agricultural profitability and would help conservation of forests and ecosystem services (Semwal *et. al.,* 2004).

Of late, realizing the immediate and long-term benefits of agrobiodiversity maintenance, efforts are being made, though still sporadic, by some government, non- government and voluntary organizations to conserve this vital genetic resource of Uttarakhand for the sustainable development of marginal hill farmers. The results are gradually becoming visible as many of the traditional lesser known crops are now being sold in the local and regional markets. In high altitude (>2000m) villages of Nanda Devi Biosphere farmers' innovations led to cultivation of medicinal species viz., *Angelica glauca, Carum carvi, Dactylorrhiza hatagirea, Meggacarpaea polyandra, Pleurospermum angelicoides* and *Saussurea costus* in recent years which were earlier harvested from the wild (Nautiyal *et. al.,* 2001). As these species are rare and endangered, their cultivation falls in line with the goal of conservation of wild biodiversity. According to another study by Silori and Badola (Paper Published in Mountain

Research and Development, 2000) in five villages in Pithoragarh district 12 different species of medicinal plants are cultivated by farmers on their private agricultural land. Of the total species of medicinal plants under cultivation, six are being marketed while the remaining six were under nursery plantation for further propagation at the time when the study was being carried out in 1996. On average, a household earns about Rs. 2423 per season from the sale of medicinal plants. Similarly at lower altitudes (500-1500m), in some locations, a few farmers have started cultivating *Cleome viscosa* (Maikhuri *et. al.,* 2000b). Just a few years back this unsown crop used to be casually managed by local farmers for its seeds in their rainfed fields during kharif season. The seeds of *C. viscosa* gradually became popular as a condiment for their piquancy and at present fetch good economic return for farmers who cultivate it. It was estimated that when grown as monocrop the net return was Rs. 10, 520 ha^{-1}; as a mixed crop 4,463 ha^{1}; and when grown in fallow land the net return was 1,540 ha^{-1} (Maikhuri *et. al.,* 2000).

Cultivation of medicinal plants has been taken up by local

Mustard & wheat cultivation on terraced fields

Concerted efforts in terms of rigorous scientific studies on redevelopment of traditional agroecosystems, technological intervention to minimize extreme human drudgery, policy and institutional support for agrobiodiveristy conservation, and exploring market linkages are some of the essential prerequisites to keep getting immediate and long term benefits from this precious resource.

Forest, Agriculture, and Animal Husbandry Linkages

As has already been mentioned, the traditional agriculture of Uttarakhand is closely linked with forests and therefore essentially needs a massive input from it. It has been estimated that annually a hectare of cultivated land requires 11.5 t fodder, 7.4 t fuel wood and 3.4 t bedding leaves in Uttarakhand (Singh *et. al.,* 1994). This is generally one-way flow of nutrients from the forest to the agricultural fields. Agricultural productivity depends on the forests as these provide a significant amount of fodder needed to sustain a huge (nearly 4 million) livestock population comprising cattle, buffaloes, sheep and goats, and leaf litter needed to produce farmyard manure (FYM). About 2-10 units of energy from forest ecosystems are required to obtain one unit of grain energy from agroecosystem in this part of Uttarakhand (Pandey and Singh, 1984; Singh *et. al.,* 1984; Ralhan *et. al.,* 1991). In terms of area, it has been estimated that 2-15 ha of forest area might be required to sustain productivity of each ha of cropland (Singh *et. al.,* 1984; Rao *et. al.,* 2005). Farmers may practice long-term fallowing, use chemical fertilizers and plant fodder species when natural forests could not meet manure and fodder requirements (Rao and Saxena, 1996).

Undoubtedly, the productivity of crops increases due to the nutrient subsidy received from the forests. Studies have reported reduction in soil carbon and nitrogen in the forest from where litter removal is high (Thadani and Ashton, 1995). As economic constraints and ecological risks restrain use of synthetic fertilizers, application of FYM remains the sole option to replenish soil fertility accounting for about 50-60% of the total energy input (Semwal and

Maikhuri, 1996). Barring some cash crops like potato, traditionally, Rabi season crops receive greater amount of FYM than Kharif season crops. In this regard the crops grown in irrigated fields are given priority by local farmers than those grown under rainfed condition as the yield under former is more assured. The range of FYM application may vary from 3 to 28 t ha^{-1} depending up on the availability of forest resources and also on the crop and its importance to farmers. As far as quality of FYM is concerned, it primarily depends on the type of bedding leaves (organic resource), quantity of dung and the state of decomposition at the time of its application to the crop fields. Often, partly decomposed manure is applied at all the altitudes. This type of FYM though adds humus to the soil, remains poor in nutrients release (Swarup, 1993). Among all the three agro-climatic zones, the farmers of middle altitude depend on poor quality organic resource, mainly constituting pine (*Pinus roxburghii*) needles that constitute the dominating forest type at this altitudinal zone in Uttarakhand. Scientific studies are required to facilitate production of quality FYM, and establish synchrony between nutrient release and crop uptake. Otherwise generally nutrients are not necessarily released at the time of peak crop demand and may leach from the system without being utilized.

Farm Yard Manure heaps consisting of decomposed forest leaf litter, animal dung and urine is the main source of replenishing soil fertility of crop fields

In money terms for the agronomic yield (grain and crop residue), forest resources worth two money units are spent to get one money unit of agronomic yield (Table 2.3.3). This calculation indicates that traditional mountainous agriculture is non-viable on money terms. Similarly, when fodder is not considered the output-input ratio for livestock would compute to 4.5, but would become 0.2 when the fodder is valued. Thus, within the existing situation in which the cost of forest resources is externalized, functioning of both the agriculture and livestock rearing systems looks viable. However, once the cost of forest resources is internalized, the agro-ecosystem functioning becomes non-viable.

Table 2.3.3: Output-Input Rratio for Agroecosystems of Uttarakhand (adapted from: Singh *et. al.*, 1992). All values are based on per ha of cropfields.

Input - Output	Value (when human labour and forest resources are not accounted) (Rs ha^{-1} yr^{-1})	Value (when both human labour and forest resources are accounted) (Rs ha^{-1} yr^{-1})
Input costs	2,100	26,320
Output value	12,600	12,600
Profit/Loss (Rs./ha/yr)	10,500	13,720
Output-input ratio	6.00	0.48

Yield and Economic Value of the Crops

Lack of comprehensive studies and consequently reliable data on the yield potential of the various traditional crops grown in the region make it difficult to put any precise figure in this regard as the yield of crops in Uttarakhand. Some sporadic studies carried out by different workers reveal that the yield of the crops varies significantly in different parts depending on a number of factors e.g. irrigation facilities, quality and quantity of the inputs applied, altitude, climatic, and edaphic factors. Crops grown under irrigated condition often give higher productivity than those grown in rainfed agriculture.

Based on few estimates it has been observed that the yield of rice and wheat under irrigated condition in Uttarakhand is some times higher than the national average. In the rainfed agriculture of the Uttarakhand, some of the crops like paddy, soyabean, sesame yield higher quantity of grains in the lower altitude areas; wheat, barnyard millet, finger millet, foxtail millet, maize, mustard, and many pulses in middle altitude; and potato, amaranth, buck wheat, barley, naked barley and kidney bean in the higher altitude. In the inner Himalayan valleys and slopes of Uttarakhand where the forests are thick and soil fertility and moisture are not a limiting factors, productivity of crops is generally higher as compared to other parts of the state. While taking cropping seasons into consideration across the altitudinal gradient and irrigated as well as rainfed agriculture, it has been observed that the yield of Kharif season crops is generally higher than the Rabi season crops (Semwal *et. al.,* 2001).

According to some figures the average productivity per hectare of crops in Uttarakhand is 1.63 t ha^{-1} for some cereals and millets; 0.6 t ha^{-1} for pulses; 0.7 t ha^{-1} for oilseeds; and 22.7 t ha^{-1} for potato (State of Environment Report, 2004). Whittaker (1984) has reported the average grain yield of the crops in Garhwal to be about 2.0 t ha^{-1}. Maikhuri *et. al.,* 1996, while describing the traditional agroecosystems of Garhwal Himalaya at different altitudes have reported the average yield of different crops at 1.02 t ha^{-1} for wheat; 1.1 t for barley; 2.61 t for mixed crop of paddy, barnyard millet, and foxtail millet under rainfed condition; 1.81 t for mixed crop of finger millet and horse gram; 1.85 t for amaranth, and 9.86 t $ha-^{1}$ for potato. The grain yield of wheat under irrigated condition has been recorded at 2.23 t $ha-^{1}$ Semwal and Maikhuri (1996) in outer Garhwal have recorded very high yield of various mono and mixed crops of cereals, millets and pulses under rainfed and irrigated conditions from 2.35 t ha^{-1} to more than 4.0 t ha^{-1}.

Field experiment carried out by Negi (1994) on traditional vs. HYVs of wheat under irrigated and rainfed conditions showed that the grain yield of HYVs was more in irrigated condition than the traditional varieties while reverse was found true under rainfed condition. Moreover, the crop residue out put of traditional varieties was recorded significantly higher than HYVs. Yet another experiment conducted by Singh (1995) in Henval valley of Tehri Garhwal supports that the traditional land races of rice yield more than HYVs not only in grains but also in the by-products. Thus if the conditions are suitable, some of the traditional crop varieties are not less productive than the improved varieties particularly in the mountain environment.

The total value of agriculture produce of the Uttarakhand state was Rs. 10,761.5 million for cereals; 348.3 million for pulses; and 238.7 million for oil seeds and 7,355.3 million for other crops including potato, and sugarcane. Agriculture contributes around 37.3% to state GDP (01-2002)

(Source: http://www.eUttarakhand.com/Uttarakhand/agriculture_irrigation.php)

Horticulture

Horticulture in the mountainous regions is an obvious choice to augment income from farms as climatic conditions are congenial for horticultural development. It has the potential not only to stabilize the agricultural economy but also to simultaneously promote environmental conservation, and minimize human drudgery. However, recklessly going for the monoculture of a particular fruit crop indiscriminately (as is happening) has more hazards than the benefits. At present an area of 1918 km^2 is under various fruit and vegetable cultivation in the state (Uttarakhand SoE, 2004). This system became popular largely because of the economic incentives and monetary profits to the farmers ensured through government subsidy and market demands. A large scale extensification of horticulture often lead people to encroach upon ecologically and socially valuable oak forests, demands of packing material on surrounding forests (earlier to prepare wooden cases from pine wood and now removal of large quantities of pine needles) put pressure on surrounding forests and leads to their degradation. Socially, big farmers have derived more benefits than small and marginal farmers. Thus, efforts need to be made to diversify the horticultural land use in the state by integration multipurpose indigenous fruit and fodder yielding trees with commercial horticultural crops and also developing some additional mountain specific agricultural activities like floriculture, apiculture and mushrooms cultivation (Semwal *et. al.,* 2001).

Horticultural development sometimes put substantial pressure on ecologically important high altitude forests

Conclusions/Recommendations

The forests provide the resource base for maintaining the agro-pastoral economy in the mountainous areas of Uttarakhand. The traditional crop diversity and their numerous landraces in agricultural land use in the state have importance for the sustainability of traditional agroecosystems, household food and nutritional security, future innovations along with conservation and maintenance of various ecosystem services such as biodiversity, scenic beauty and hydrological regulation that benefit a larger community.

As traditional land use in mountains is characterized by its dependence on locally developed technologies, in changing socio-economic scenario, economic incentives have to be devised for local farmers for the conservation for crop diversity. The extreme drudgery involved requires mountain specific technological solutions, and for efficient use of forest resources and enhancing productivity scientific inputs are urgently required. Mechanisms have to be developed to link local economic development with forest resources through appropriate policy and institutional arrangements. For this to happen, sound scientific knowledge should be generated on the traditional biodiversity rich agriculture for its redevelopment.

A huge opportunity has arisen now in terms of growing demand for organic food, improving scientific knowledge on the nutritional qualities of traditional crops, and identification and increasing demand of coarse cereals and millets in confectionaries and urban households. This may make the hill agriculture economically remunerative. Capitalizing upon the ecological heterogeneity of the state which gives it comparative advantage of growing certain cash crops including those traditional crops having market demand such as amaranth, buck wheat, Cleome, medicinal plants can make farming of this region economically viable, and at the same time socially equitable as more than 80 % of the local population is involved in agriculture. However, the measures taken so far are still scanty and sporadic.

A new area of research could be to look these crops as multipurpose crops having value more than food. Some of the crops are traditionally considered having medicinal properties. In addition, scientific knowledge has to be generated to improve the quality of agricultural inputs such as FYM, establishing synchrony between nutrient release from FYM and crop up take, classify agriculture soils, strengthening traditional agroforestry, and animal husbandry. The ecological role of these crops could also be explored as these may be contributing to generate ecosystem services like carbon sequestration, hydrological regulation, scenic beauty, soil fertility maintenance, and minimizing soil erosion.

Majority of Land holdings (>70%) in the mountainous part of Uttarakhand are marginal and scattered. Working to find out suitable models for agricultural land consolidation, strengthening traditional agroforestry, and integrating horticultural crops may help ensure conservation of agrobiodiversity, food and nutritional security; enhance household economy; and minimize human drudgery.

Policy and institutional support for providing economic incentives to local farmers for maintaining agrobiodiversity, local value addition, establishing market linkages, and technological interventions for minimizing human drudgery and enhancing productivity.

Forest, agriculture, and animal husbandry are the interlinked production systems, there is a need for developing integrated institutional mechanisms for decision making and establishing strong interdepartmental cooperation for information sharing.

Agricultural terraces in the forested landscapes create a situation of unmatched scenic beauty, these terraces may help in hydrological regulation, carbon sequestration etc which could be scientifically evaluated and valued

Out migration is leading to agricultural land abandonment particularly of rainfed agriculture which is rich in traditional crop diversity in Uttarakhand. The phenomenon is responsible for land degradation, loss of agrobiodiversity, and traditional ecological knowledge associated with farming. Addressing to above recommendations may help minimize out migration.

2.4. Hydrological Regulation (Role of Forests in Maintaining Hydrological Services)

Studies from Uttarakhand record many instances of accelerated soil erosion, landside/slip activities, increased flood hazards and diminished discharge in springs and rivers, all associated with forest degradation and loss of forest cover (Valdiya, 1987). The conversion of forests to agricultural fields has been known to accelerate soil losses by 5-10 times (Rawat and Rawat, 1993). One field survey confirms that degraded forestlands shed more runoff and lose more soil than those, which retain a forest cover (Haigh, 1982).

However, this is easier said than done as to prove the role of forests in regulating the hydrological services for which more scientific data is essential. Scientific knowledge for managing hydrological services is still limited (Kremen, 2005).

A brief on Watershed Services

Forests affect both water quality and water quantity (total as well as seasonal variations). Forests vegetation has a large "sponging effect", soaking up and storing rainwater, and releasing it gradually later on. Consequently, a forested watershed buffers the impact of downstream flood or drought. This ecosystem service is of great local and regional significance, but is not easily measurable. However, during monsoon, in which nearly 80% of the total rain fall occurs within a short span of 3-4 months the sponging function of the forests may have limited role in regulating the flow of entire amount of water because of too much water in too short a time.

Dense forest, shrubs and clean water are interrelated

The impact of forests communities and habitats primarily depends on whether evapotranspirational loss is more or less than the water retained by the sponging effect. The sponging effect of the forest is largely because of the organic matter generated by litter (both aboveground and belowground litter, pores, tunnels) and slits created by dead roots and soil fauna. Forests improve water quality by decreasing soil erosion and filtering pollutants from water. About 3,400 public water systems in the USA alone depend on the services of forested watersheds.

Apart from the consumptive uses, water quantity influences several recreational activities, such as fishing, boating and rafting. The other non-consumptive use of stream flows include electricity generation. Forests by controlling soil erosion improve the functioning of turbines. Then, there are passive use values of stream flows, as many habitats, species and conditions depend on them, and there are people who are willing to pay for the maintenance of stream flows (e.g., US$ 95 household^{-1} yr^{-1} for natural stream flow of 11 Colorado Rivers). People have found to value the knowledge that the habitats, species and conditions on which water flow are depends preserved.

Forest ecosystems contribute to water quality by detoxifying environment (accomplished by soil and litter invertebrates and microbes) and removing pollutants (pesticides, heavy metals, nutrients and other) and preventing erosion of hill slopes and silt deposition in downstream water bodies.

Case Studies from Uttarakhand

There are only few Universities government research institutions that are located in the high mountain regions of developing world and fewer still with the resources and expertise to tackle the very demanding discipline of hydrological monitoring. In a study entitled "Hydrologic cycle in Forested and Deforested Watershed Systems, central Himalaya India in 1994, Rawat attempted to document the role of forests by comparing two catchments one forested and other deforested in maintaining the hydrological behaviour. The recorded sediment yield of the forested catchments was several times smaller than erosion or sediment rates recorded from catchmats suffering from human disturbances. The study revealed that during rainy season reveal that high intensity monsoon rains on a forested catchments produced a peak water discharge of 168 L sec^{-1} km^{-2} including peak suspended concentration of 570 mg L^{-1}. The disturbed non-forested catchments recorded a peak water discharge of 761 L sec^{-1} km^{-2} including 901 mg L^{-1} suspended concentration. The result show that during rainy season the non-forested disturbed land contributes several times more storm runoff and higher sediment yields compared to the undisturbed forested land (also see Chapter 4).

Rawat (1998) in an experimental study in the micro-catchments of the Kumaun Himalaya revealed that about 50 percent changes in water flow capacity are man-induced. In the month of the heaviest rainfall, i.e., July (under identical geological geomorphological character, and climatic conditions), agriculture land generated the highest amount of water discharge (i.e. 8734 m^3 day^{-1} km^{-2}) coupled with maximum flow of suspended (i.e. 1.6 t day^{-1} km^{-2}) and dissolved (i.e. 2 t day^{-1} km^{-2}) silt load, while oak-mixed forest land generated the minimum water discharge (i.e. 4874 m^3 day^{-1} km^{-2}), coupled with minimum flow of suspended (i.e. 0.06 t day^{-1} km^{-2}) and dissolved (i.e., 0.40 t day^{-1} km^{-2}) load. In the driest month, i.e., April the flow capacity of the same land is quite opposite. Agricultural land generated the minimum water discharge (i.e. 180 m^3 day^{-1} km^{-2}), without suspended material, with dissolved load only 0.07 t day^{-1} km^{-2}, while the oak-mixed forest land generated the maximum water discharge (i.e. 307 m^3 day^{-1} km^{-2}) without suspended material coupled with dissolved load amounting only 0.02 t day^{-1} km^{-2}. In general, people perceive that an oak forest is better than a pine forest in water and soil retention. Sediment flow data of catchments indicate that the intensity of suspended and dissolved silt load flow was higher in from the agricultural land than of forested land due to anthropogenic influences.

Jyoti and Bisht (1995) conducted a study in a pair of the micro watersheds of a Lesser Himalayan terrain. Both the catchments have similar slope, climate and other physiographic characteristics but different landuse types. One of these watersheds was completely forested (mixed forest of mainly oak and pine) and the other one was disturbed by arthropogenic activities. Continuous measurements of drainage basin input (temperature, rainfall, humidity) and outputs (surface, runoff, evaporation and channel runoff) in quantitative terms revealed that during the year 1992 about 80952 m^3 water discharge coupled with 1.1 t suspended and 2.7 t dissolved load flowed through the mouth of the forested watershed. From the deforested watershed these values were recorded as 70,198 m^3 water discharge with 1.6 t suspended and 2.78 t dissolved load. It was observed that water discharge was high in the forested catchments through out the year compared to the deforested catchments as the forest cover helps in recharging the ground water.

Loshali *et. al.*(1989) studied overland flow and soil management on small plots of three forest types in the Kumaun Himalaya. Average seasonal (June through September) overland flow (measured over two years) was 0.49% of the seasonal rainfall (1967 mm) and was always less than 1% of each rain event (there was less than 0.1% difference among forest types). Seasonal soil movement ranged from 2.3 to 3.2 g m^{-2} among forest types and averaged 2.6 g m^{-2}. Both overland flow and soil movement were significantly different between months, being positively correlated with amount of rainfall. Sediment concentration of runoff water did not vary among months by more than 0.1 g L^{-1}. The study indicates that steep, forested slopes are not an important sediment sources in Kumaun Himalaya.

Effect of Forest Types in Rainwater Partitioning

Hydrological parameters, such as through fall, stem flow, runoff and interception loss, depend upon the amount and intensity of rainfall, the density of the tree crowns and the branching pattern of trees.

In a study conducted in the buffer zone of Nanda Devi Biosphere Reserve (NDBR) (Negi *et. al.,* 1998) it was found that tree crown architecture and physiognomy determine the partitioning of rainwater within a forest ecosystem. The oak has a round canopy and the pine and silver fir are conical in shape. Comparison of the different forest types (Table 2.4.1) indicated that between the low altitude oak and pine forests, canopy interception of pine is higher (i.e., it permits lower amount of rainwater to reach the forest floor) and about one third of the incidental rainfall is evaporated back to the atmosphere from the tree canopies. The oak forest allows more water to penetrate to the ground floor and hence more infiltration. The soil loss from the oak forests was also found about half as compared to the pine forests. Similarly, in the high altitude forests kharsu oak forests were found superior with regard to water infiltration and conservation of soil as compared to the conifer species (*Abies pindrow).*

Table 2.4.1: A Comparison of Hydrological Response between Oak and Pine Forests and the High Altitude Forests of Uttarakhand (Values are percentages of gross rainfall)

Hydrological parameters	Low altitude forests*		High altitude forests**	
	Oak	Pine	Kharsu Oak	Silver fir
Canopy through fall (%)	79.2	66.5	79.8	72.5
Stem flow (%)	0.44	0.31	0.09	0.01
Canopy interception (%)	20.1	32.4	20.1	27.5
Overland flow (%)	0.39	0.94	0.31	0.01
Infiltration + Forest floor interception (%)	79.3	65.9	79.8	72.5
Sediment loss (Kg ha^{-1})	19.2	33.5	16.3	9.2

* Values adapted from Pathak *et. al.* (1983 &1984), Mehra *et. al.* (1985) and Loshali and Singh (1992);
** Values from Negi *et. al.* (1998).

All these studies lend support to the role of Himalayan forests in regulating the hydrological behavior.

Hydro-Electric Power in the Himalaya

In India, 26% of the total power or over 32,000 MW, is generated through hydro-electric projects (HEPs) (Government of India, 2005). Most of the power generation in the Himalayan states such as Uttarakhand and Himachal is through HEPs. Recent construction activities of a large number of HEPs will make these states have huge power surpluses which will generate substantial revenue and, by helping attract industry, contribute significantly to the economy of these states.

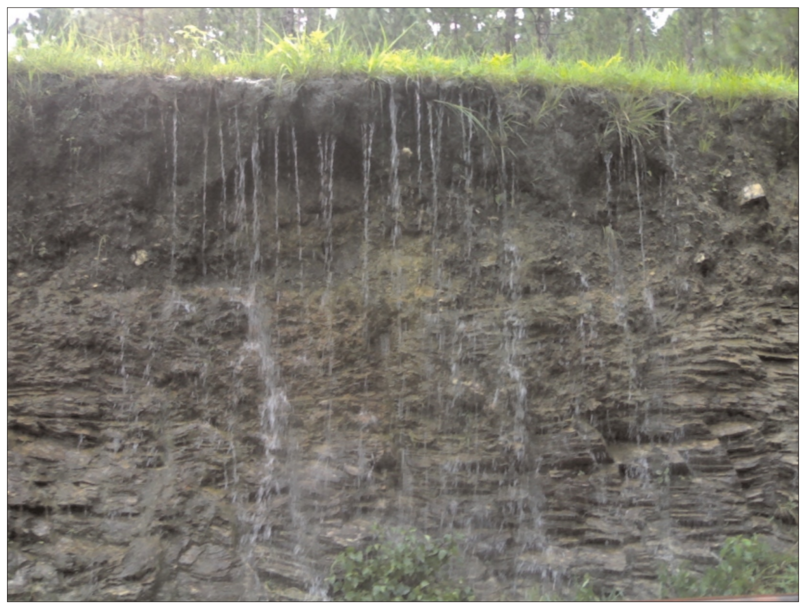
The young and rising Himalayan ranges are highly susceptible to landslide/landslips and erosion. The Ganga-Brahmaputra river system carries the higher sediment load than any other river system in the world (Wasson, 2003). Hydro-electric projects are dependent on the regular flow of clean water for efficient operation. The degradation of Himalayan watersheds results in increased silt flow which inhibits the normal functioning of HEPs. To sustain the flow of ecosystem services, a type of Payment for Ecosystem Services (PES) mechanism the Catchment Area Treatment plan has been mandated by law. However, due to poor implementation of these plans, there has been little improvement in ESs despite a large commitment of funds (Thadani, 2006).

Land Use and Soil Erosion

Available literature indicates a huge range of soil loss and runoff even when similar land use is being considered. For example, a review carried out by Negi (2002) finds that runoff (as a % of rainfall) values range from 1-37% for croplands, 5-86% from grasslands, and 0.01-2.17% for forests in healthy condition. Soil loss varies from 0.3-37 t ha^{-1} yr^{-1} in crop land; from 1.9-565.3 t ha^{-1} yr^{-1} for jhum-fallow cycle, and 0.01-0.06 t ha^{-1} yr^{-1} from forest.

While some of the huge differences in figures is due to methodological and geological differences (substrates, parent material and slopes), a large part of it is accounted for by differences in land use and land management. A well managed forest can thus cut down silt flow to 1% or so of a poorly managed landscape. The value of this ecosystem service for a HEP is enormous and has only recently started being factored into economic calculations. Both conventional reservoir type HEPs as well as the more recently popularised run-of-the river type HEPs (which have small or no reservoirs) are badly impacted by silt loads.

For a run-of-the river type HEP, the case for Nathpa Jhakri HEP, located in Himachal Pradesh, is revealing. Nathpa Jhakri has an installed capacity of 1500 MW (6x250 MW). Given the high silt loads, an expensive four-chambered underground desilting complex was constructed for this HEP which is among the largest of its kind in the World. Nonetheless the project has faced repeated problems due to high silt loads and has had to be repeatedly closed during periods of high silt load thereby incurring huge financial losses. In 2005 Nathpa Jhakri project was closed for most of June and August and faced a total closure of 89 days. In 2006, there were 21 days of closure in the first 8 months of the year itself (Dams, Rivers and People, SANDRP, vol 4, Issue 9-10, Oct-Nov 2006). Most of this closure was at a time the monsoon when adequate water is available to generate at full capacity and when, due to the intense heat in the plains, power requirements are very high across the country. In 2005 over 30% of the operating revenues were lost due to closures (Thadani, 2006). The project was designed for a silt load of 5,000 ppm (parts per million) but the level of silt content has often exceeding this level and reached as high as 16,000 ppm, forcing temporary closures. These high silt loads have also eroded the metal parts of the turbine and it is estimated that parts replacement due to silt damage would cost Rs. 400 million annually (The Tribune, online edition, August 6, 2004**).** As per conservative Government estimates, up to the end of 2005 **"**The total consolidated loss suffered by Satluj Jal Vidyut Nigam Ltd on account of forced closing of Nathpa Jhakri Hydro Electric Project units on account of high silt is about Rs 3,550 million since its commissioning in 2003," (The Hindu Business Line, Dec 22nd 2005 quoting a written reply given to the Rajya Sabha by the Minister of Information and Broadcasting).



Grasslands/grazinglands help keep surface runoff clean and need to be maintained/conserved for proper functioning of hydroelectric power projects

In the case of reservoir type HEPs, siltation of reservoirs is a serious problem. While certain background levels of siltation are unavoidable, the problem has been greatly exacerbated by the degradation of ESs in the catchments of HEPs. As per an estimate, India loses 1.3 billion cubic metres of storage capacity each year which is equivalent to a loss of Rs. 14,480 million annually (Thakkar and Bhattacharyya, 2006).

Depending on slope angle hill agriculture can provide very different results for sediment yield. A study by Sen *et. al.* (1997) in the Pranmati watershed of the Central Himalaya showed that agricultural land on low sloping terraces (<2 degree slope; soil loss 0.30 to 0.66 t ha^{-1} yr^{-1}) had 10-100 times lower sediment yield than strongly sloping terraces (6-10 degree slope; soil loss 6-64 t ha^{-1} yr^{-1}).

A way of measuring the value of water purification function of forests in a watershed is the cost of constructing and operating water treatment plants to purify water. The 8 million people of the New York City receive water from the 32 km^2 Catskill watershed. In 1990s the people decided to spend US $ 1.5 billion to protect the watershed and thus keep water quality high. By doing so they saved US$ 4-6 billion as the cost of constructing a new water treatment plant and US$ 300 million per year to operate it. There are several more examples of people choosing to protect watershed forests instead of constructing new water filtration plant (e.g., Sterling forest watershed in case of New Jersey, Bull Run watershed in case of Oregon, Portland Maine see in Krieger, 2001). In these cases money actually spent to protect watershed could be taken as an appropriate measure of the value of water purification services.

Water Market and Local Innovations

The scarcity and growing need for water has prompted local innovation. Payments by water users for watershed protection are in place only in few cases in India and the number of such successful stories is still negligible. Improved forest management, reforestation and forest protection are prominent activities in evolving deals. In a world where one-fifth of the population lacks access to safe and affordable drinking water and half the population lacks access to sanitation; improving our understanding of how markets for the forest watershed protection may improve water quality and augment dry season flows is critical.

Conclusion /Recommendations

In Uttarakhand, annual precipitation is between 1,000 and 2,500 mm in much of the region (which is one of the higher side of the range on the earth) but most of it (approx. 75%) occurs within three monsoon months leaving most of the remaining months almost dry. The biggest challenge therefore is how to reduce the run off and enhance water retention for use of inhabitants during dry periods. Siltation in the Himalayan water bodies is amongst the highest in the world connected with this are deforestation, anthropogenic pressure on rivers, lakes, streams and springs which have strong linkages with forest hydrology. The streams and springs are the main water sources of rural Himalayan people as well as water to lakes, reservoirs and canal systems. The precipitation that passes through forest ecosystem and contributes to surface streams and ground water is so far the largest sources of water available to rural, people in Uttarakhand. Thus, the demand for clear water that comes from forested areas has increased greatly and will continue to rise. There is an urgent need to make people aware of this important ecosystem service emanating from the forests of Uttarakhand so forest conservation/ restoration initiatives are taken up on a priority basis. More scientific data needs to be collected to put a rest to some of the myths that surround the importance of forests in maintaining various natural hydrological regimes. A large number of HEPs are coming up in Uttarakhand; resources available for catchment area treatment could be shared with local communities inhabiting the catchments to encourage forest conservation. Alternatively local people should be given some share in total power generated by HEPs for meeting their energy requirements which inturn will minimize pressure on forests for fuel wood.

Box 2.4.1: Harnessing Seasonal Streams from Forested Areas for Agricultural Soil Fertility in Uttarakhand

As elsewhere in the Indian Himalayan Region, seasonal streams originating from the forested catchments in Uttarakhand drain water into the perennial river system. The crop fields are intersected by these seasonal streams and traditional canal irrigation system is developed by the village communities around these streams. It has been a long practice in some villages of Uttarakhand to divert the first surface overflows of streams that come from the forested catchments upstream with the occasional rainfall events during summer or with the onset of monsoon to the crop fields. It is traditionally believed that the initial turbid water flows bring organic matter and nutrient rich soil and sediments with it and enhance soil fertility and crop yield. As this phenomenon takes place only a couple of times in a year, local communities do not have any traditional norms and practices developed to use this opportunity in equitable manner as they generally do for all other natural resources. In this situation, village people with croplands located close to the canal inlet and with some influence over the community use to sequester the benefit that such initial nutrient rich flows accrue in terms of soil fertility. This is a clear example of local understanding on forest ESs and harnessing them albeit in this case benefiting only a few households at local level.

2.5. Recreational Value of Forest Landscapes of Uttarakhand

In Uttarakhand the high Himalayan ranges and glaciers cover most of the northern parts of the state, while the adjacent lower reaches are densely forested. The unique and varied Himalayan ecosystems provide habitat to a large number of charismatic animals including life saving medicinal plants and rare herbs. The mammalian diversity in the state is one of the richest in the country with over 75 species inhabiting different forest ecosystems. The vast expanses of alpine meadows locally called buggyals between timberline and snowline besides playing role in local economy are spaces of unparallel scenic beauty. The Protected Areas in the Shivalic- Bhabhar are famous for flagships like tigers and elephants while the higher altitude PAs are known for their outstanding scenic beauty world over. Two of India's most sacred rivers, the Ganga and the Yamuna take birth in the glaciers of Uttarakhand Himalaya, which are futher fed by innumerable streams originating from several cristal clear high altitude lakes and spring fed streams in the region.

Dense forests maintain scenic beauty and attract nature lovers

As mentioned above the forests of Uttarakhand from foothills to alpine meadows provide opportunities for developing recreational services for conservation and supporting livelihoods of the local communities. At present a total of (2005-06) nearly 0.2 million tourists visit the PAs of Uttarakhand generating a revenue of Rs. 25.76 million for the state. Tourism related to recreation/wildlife, adventure, and pilgrimage contributes nearly 19% to the GDP of Uttarakhand.

Some examples from Uttarakhand showcasing role of forests particularly PAs in maintaining the scenic beauty and providing recreational services are as follows:

Eco-Tourism in Corbett National Park

Corbett National Park (CNP) located in the foothills is the first National Park created in India way back in 1936 is one of the most important destinations for wild life tourism in the country. After the launch of Project Tiger in India in 1973, CNP became the part of Corbett Tiger Reserve (CTR) consisting of the CNP, Sonanadi Wildlife Sanctuary, and parts of some adjacent Reserved Forests. Tourism in CNP/CTR remained more or less static till the eighties. A limited number of visitors came and stayed inside the National Park in accommodation at twelve different places, there being only one tourist complex at Dhikala with limited accommodation. Accommodation in other places consists of Forest Rest Houses, most of them having been constructed during the colonial period. Visitors would come in their own vehicles, bring their own provisions as food was available at Dhikala only, and enjoy wildlife by driving around, sitting in the watchtowers or going on elephant rides, interpretation facilities at Dhikala, audiovisual shows at Bijrani and Dhikala, and museum at Dhangari. However, Ramnagar township located on the boundary of CNP, where the headquarters of CTR is also located, remained unaffected by tourism during this period (Bhartari, 2001).

During the nineties there was a sea change in both the numbers and pattern of visitation. The number of tourists increased dramatically from 33,047 in 1991 to more than one hundred thousand in 2005-06. Today CNP generates highest revenue from tourism than any other PA in India. According to Uttarakhand Forest Statistics 2005-06 the number tourists in the CTR has been rising consistently and was close to 130,000 in 2006. In this the number of foreign tourists was 8,523. The total revenue generated was approximately Rs. 19.20 million. To further promote the activity, community based tourism (CBT) is being promoted in the CTR to share conservation benefits with local people and sensitize tourists. For this a training centre has been created in 2003 at Chunakhan near Ramnagar to train local youths and institutions in various aspects of CBT.

A herd of elephants at Dhikala Chaur in CTR

Nanda Devi Biosphere Reserve (NDBR)

NDBR represents a unique set of ecosystems including mixed conifer broad leaved temperate forests, vast alpine meadows, a number of high snow clad peaks and glaciers covering over 2,200 km^2 of Himalayan wilderness including the second highest (7817 m) sacred peak Nanda Devi "the bliss-giving goddess" of India. A total of 17 villages including four uninhabited are situated in the buffer zone of NDBR with nearly 3000 inhabitants mostly Bhotiya tribal people living in the remaining villages (Maikhuri *et.al.,* 1998).

The occurrence of rare and endangered species of mamals like snow leopard, brown bear, Himalayan tahr, musk dear etc., birds like monal, snow cock and snow partridge make the area of immence conservation value. Realising this it was declared a Wildlife Sanctuary in 1939, National Park in 1982, Biosphere Reserve in 1988 and in 1992 UNESCO declared it as World Heritage Site.

Since the establishment of the Nanda Devi National Park in 1982, local Bhotiya community living in the vicinity of the PA faced abrupt and unileteral curtailment in their social, cultural, and economic rights over surrounding natural resources. The complete ban on harvesting of forest resources, grazing, trekking, and mountaineering within the PA impacted the local economy adversly that had already suffered a blow by the closure of the Sino-Indian border trade in 1962. Promises of redress have largely gone unfulfilled and the ensuing resentment against conservation authorities have led to recent struggles to regain communal rights over the resources of the NDBR.

Box2.5.1: Tourism in NDBR

Since 1982 the local people as well as tourists were excluded from the core zone of NDBR (625 km^2 area) hampering the local economy. Further, in the buffer zone villages of the PA loss to the mean annual income per household was estimated at Rs. 1285; Rs. 1195 and Rs. 156 due to damage caused by wildlife to food crops, fruit trees and bee hives, respectively; Rs. 1587 due to ban on collection of wild medicinal plants for marketing and Rs. 7904 due to ban on tourism in the core zone that otherwise offered seasonal employment to local people through their engagement in various trekking related activities (Maikhuri *et. al.,* 2000 & 2001).

Annual income to the local people from tourism before establishment of Nanda Devi National Park in 1982

Employment/ Income	1962-1971	1972-1981
Employment days $capita^{-1}$ yr^{-1}.	215	235
% people engaged as porters	78	85
% people engaged as guides	22	15
Wages (Rupees) earned by porters yr^{-1}.	822,375	2,157,300
Wages(Rupees) earned by guide yr^{-1}.	404,200	676,800
Total money earned (Rupees) yr^{-1} .	1,226,575	2,834,100
Total money(Rupees) earned per person yr^{-1}.	5,652	11,808
Average income to Buffer Zone village community (Rs. $household^{-1}$ yr^{-1}.) Mean of 10 villages of buffer zone	7,823	7,904

Ban on tourism has created conflict between local people and PA authorities as it provided significant income to the local people (Maikhuri *et. al.,* 2000). The major attoractions for tourists here were adventure to climb some of the majestic Himalayan peaks (>6000 m high), explore the natural beauty, flora and fauna of the high Himalaya (Maikhuri *et. al.*, 2000).

Mountaineering in NDBR was the major source of income for the local people before 1982

In 2001, with the region coming under the newly organized state of Uttarakhand, the government began looking to open the reserve for eco-tourism. The State tourism ministry was eager to promote recreational and adventurous tourism in the new state in general and in NDBR in particular. However, much to the dismay of the long suffering communities, the Indian Mountaineering Foundation (IMF), was given access to the restricted core area of the reserve. In 2002, after the election of a new state government, senior forest officials, social activists, and village leaders began working together on a new plan to open the reserve to regulated tourism more along the lines proposed by the local communities. In the spring of 2003, local villagers were given limited access and explicit management rights to trekking in the core zone after being banned for 20 years. However, the struggle for control of local resources continues.

The Valley of Flowers National Park

Located in the Chamoli district of the state, the Valley of Flowers National Park has been recently recommended as an extension to NDBR. The valley is renowned for its outstandingly beautiful meadows harbouring many endemic flowering plants and is also home to rare and endangered animals, including the asiatic black bear, snow leopard, brown bear and blue sheep. IUCN's report also emphasized the potential socio-economic and conservation benefits of developing eco-tourism in this remote but beautiful mountain environment (http://www.iucn.org/en/newsagencies).

The Valley of Flowers (VoF) is located between Latitude 30° 41' and 30° 48'N, and Longitude 79° 33' and 79° 46'E with a total area of 87.50 km^2 and altitude ranging from 3,200 m to 6,700 m amsl. In ancient literature it is know as *Nandankanan* - a garden so beautiful that it really belongs to Gods. The main valley portion of the Park runs in the east- west direction along the banks of river Pushpawati. The valley remains covered under thick snow throughout long winters and with the advent of summer, the melting snow leaves a trail of colours created by the flowering plants like primulas, geraniums, potentillas, gentians, iris and rare blue poppies. In spite of inaccessibility a large number of nature lovers, researchers, ecologists from accross the globe wish to visit the valley. The number of tourists visiting the VoF were first 3,742 persons in 2003-04 showing a rise of over 1,000 tourists per year which increased to 5,108 in 2005-06. The total revenue generated was Rs. 362,000 in 2005-06 (Source: Uttarakhand Forest Statistics).

Blossoming plants in valley of flowers

A spatio-temporal approach to estimate the optimum number of tourists in the VoF using criteria like *Use Levels, Transportation to reach the Site, Recreation Opportunity, Desired Resource Conditions and The Acceptable Level of Impact,* revealed that at any given point in time, the number of sensitized tourists inside the Valley should not be more than 150 persons. However, this number has no meaning unless effective sensitization is done and the tourists within the valley are truly environment lovers. In this regard, Uttarakhand government has fixed certain tariff for trekking in forest landscapes and PAs of the state. This has been done for generating additional revenue, regulating the number of tourists, and thus minimise negative impacts on environment.

Ecosystem Services by the Lake Nainital Watershed-Reduction in Silt Load due to Forests (*Source: Final Report submitted by Singh, S.P and Gopal, B in 2001-2002 to Environmental Economics Research Committee under the World Bank Aided India Environmental Management and Capacity Building Project*).

Lake Nainital and its forested watershed provide a lot of direct and indirect use values. One such ecosystem service is reduction in silt load in the lake due to forests and the subsequent cost savings on desilting activities. Estimates suggest that the soil and silt loss during rainy season in forested area is only 12.1% that of non-forested areas implying the role of the forests in minimizing soil loss, which is about 3,175 t per year from the entire catchment.

Table 2.5.1: Reduction in Silt Load due to Forest Cover in the Lake Nainital Catchments

Parameter	Value
Silt erosion from forest area	0.045 t ha^{-1} yr^{-1}
Silt erosion from non -forest area	3.72 ha^{-1} yr^{-1}
Amount saved by the forested area	3.675 t ha^{-1} yr^{-1}, 3157 t from entire catchment
Removal cost of 3157 t of silt	Rs. 192, 000 yr^{-1}

***Note:** This is the lower estimate of the removal costs. In actual practice, the amount would be much higher, as the marginal cost of removing silt would increase non-linearly with every kg of silt removed.*

The cost of removal of silt from the lake is about Rs. 200,000 annually for the amount of deposition of silt. However, not the entire amount of silt can be removed, parts of it get accumulated as delta; a certain portion accumulates in the deeper beds of the lake, reducing its capacity and quality of water. Obviously, the total cost that the forests save is much higher. In much of the catchments of the lake oak forest dominates, which is characterized by deep root system and high capacity for water retention in the ecosystem.

A view of Nainital lake & its forested catchment

The description given in Table 2.5.2 summarizes the services and the saving in costs from those services. The supply of naturally filtered water without any treatment for the drinking purpose is a good example of cost saving that is already in practice. However, the ban on swimming and fishing subsequent to the water pollution can be considered to the cost of not managing the lake properly.

Table 2.5.2: Ecosystem Processes and Services Generated from the Forests of Lake Nainital Catchments

Hydrological regulation	Services	Possible valuation examples
Water filtration (forest, valley-fill, previous rocks)	Reduced cost of water treatment	➢ Lower cost of treatment per unit water ➢ Direct water supply without treatment
Water retention within watershed (forest, valley-fill, previous rocks)	➢ Increased extra-monsoon water availability and the tree growth ➢ Higher water level in the lake	Increased turnover of water of, increased hill protection More boating, ➢ Can lead to revival of swimming and fishing ➢ Can be measured as importance given by tourists to springs, high water level in the lake and lower pollution
Forest canopy interceptions and reduce overland flow	Less siltation Dampened flood peaks	Reduced cost of silt removal
Forests	Beauty, biodiversity, soil formation	Activities related to photography, bird watching, etc. can be measured as importance given by tourists to them

Tourism Value of Lake Nainital

The total tourists visiting Nainital are close to 0.4 million per year (Source: final technical report submitted to EERC, 2001-02 by Gopal and Singh). The analysis and results based on 246 tourists falling in 56 zones show that the value derived from tourism for the Lake Nainital and its watershed is to the tune of Rs. 4.3 million (i.e. Rs. 3,020 per ha) to Rs. 6.5 million (i.e. Rs. 4,260 per ha) (Source: Integrated Management of Water Resources of Lake Nainital and its Watershed: An Environmental Economics Approach).

Other Tourist Destinations in Uttarakhand

Roopkund is visited not only for its mysterious human skeletal remains but also for picturesque high altitude meadows *en route* and the famous cultural event *Nanda Devi Raj Jat* that takes place once in every 12 years. The approximate number of tourists other than socio-religious visiting the area is 700 Indians and 250 foreigners per year. There is a Forest Rest House and Garhawal Mandal Vikas Nigam rest house at the last human settlement Wan. (Source: Rawat, *et. al.,* personal communication FRI, Dehradun)

Table 2.5.3: Total Number of Tourists Visiting Roopkund between January and December 2005 and Revenue Generated (Source Forest Check Post Bedani Records, 2005)

Total Tourist	Indians	Foreign	Revenue Genenrated
536	313	223	Rs. 53,010

Similarly the entire Bhagirathi valley beyond Uttarkashi township to Gangotri, on an average, receives visitor comprising both pilgrims and tourists in flow of 1500-2000 persons (May - October) per day in the peak season while Yamunotri the average number of visitors is between 500 and 1000 per day (Source: I. Kathivel, Sanjay Mahar and S.C. Bagri. Tourism Policy and framework for further growth and development in Garhwal Himalaya). Apart from the above well known scenic sites there are other areas in the state such as Har-Ki-Doon, Panwali Kantha-Sahastratal-Kush Kalyani, Dudhatoli forest ranges, Binsar, Munshyari, Chaukori, Kunwaripass, Rudranath, Madmaheshwar etc. to name a few among many where the tourism potential still to be harnessed fully. The temperate broad leaved and conifer forest landscapes between 1400 and 2000 m amsl in the state also have the potential to draw nature lovers in large number, especially during spring season, when majority of flowering tree species e. g. rhodendrons create picturesque view with pleasant climatic conditions.

Nanda Devi "Rajjat" near Bedni Bugyal

The scenic beauty of dense deodar forests attract tourists in large numbers in Himanchal Pradesh

Tourism and Local Communities

It is true that tourism gives rise to a great deal of secondary and tertiary economic activities, which add to jobs and incomes to local communities. There is a substantial potential for earning foreign exchange by promoting quality tourism in the state. For mountain people the benefits can be much more direct while promoting tourism. There is considerable employment opportunities in construction, particularly construction using local designs and motifs and local materials, hostelries and tourist camps, transportation, the operation of tours, organizing expeditions, trekking, camping, boating, winter and summer sports, angling and fishing.

Then there is indirect employment opportunities in the areas like agro and fruit processing, handicrafts, transport and wholesale and retail trade catering to the various needs of tourists (Dhar, 1987). Thus, it may be concluded that mountain tourism can generate direct and indirect employment; enhance foreign exchange resources; increase household income and help disseminate knowledge of history and culture of the destination localities. Uttarakhand Himalaya has great potential to attract people including foreigners for which sound strategies are to be put in place in order to manage sustainable tourism in the state. However, while promoting tourism, it should also be considered that unregulated tourism particularly luxury tourism, apart from negative impacts on environment may also be detrimental for cultural and traditional values of the local society. Tourists' lifestyle may prompt local youths to opt for easier/ faster way of earning money in order to emulate the same lifestyle. Every aware individual in the society knows that the easy and fast ways of earning are often against law, culture and traditions of impacted communities. Thus, it is important to develop stringent safeguards against tourism activities that are not environmentally and

As evident from the above, the forests have immense aesthetic and recreation value, which is being harnessed by different stakeholders in Uttarakhand. Efforts are afoot to generate employment for the local communities ensuring their participation in various tourism activities, particularly around PAs. Initiatives like establishing a Centre for Eco-Tourism in 2003 near CTR at Chunakhan and Public Private Partnership to ensure regulated tourism and maintenance of Forest Rest Houses in NDBR have already been undertaken. The Tourism Development Board as promoter, advisor and regulatory authority in the state, which is first of its kind in the country, can play a crucial role in developing and promote such mechanisms.

Conclusion/Recommendations

Scenic beauty of forested landscapes of Uttarakhand draws a large number of domestic and foreign tourists. Tourism has been regarded as an environmental friendly activity expanding rapidly throughout the globe. If managed efficiently, scenic beauty of forested landscapes of Uttarakhand can attract a huge number of tourists round the year. The earning from the tourist flow would benefit the local economy on the one hand and would generate resources for conserving the forest ecosystems on the other. Presently wildlife and forest based tourism in Uttarakhand generates a substantial amount of revenue particularly in PAs that are accessible for urban population, however, the conservation benefits are largely sequestered by the economically better off sections of the society. There is an urgent need to develop mechanisms for ensuring that these benefits are shared with the local people whose rights are often curtailed to create PAs and develop environment friendly and value based tourism amenities in remote areas in the state having high recreational value. Conservation organizations, donor agencies, research and educational institutions, tour operators, hoteliers, may also contribute in sustainable forest management by providing incentives to local communities.

2.6. Pollination

Pollination involves complex biological processes and ecological associations that remain poorly understood in most cases, even for agricultural plants. It is a Herculean task to estimate the value of pollination to agricultural production and natural communities. Further, in terms of economic value, it is inherently difficult to assign monetary value to a service that is crucial for the maintenance and functioning of ecosystems and of life itself. A recent estimate showed that ESs equal to US$ 33 trillion a year are generated from various ecosystems of the world, with pollination alone being responsible for US$ 112 billions (Paulo and Flavia, 2004). Similarly annual value of the ecological services provided by the wild insects in the United States of America (USA) has been estimated at US$ 57 billion assuming that the losses that would accrue if insects were not functioning at their current level (Losey and Vaughan, 2006). Pollination service provided by various pollinators include agricultural crops, horticultural crops and wild vegetation that contributes in the maintenance of biological diversity and functioning of ecosystems. Therefore, a decline in pollinators population can have negative economic and ecological consequences, manifested through reduced agricultural and fruit yields, local extinction of plants, and decline in frugivores. A few attempts to estimate the economic value of pollination services have therefore focused primarily on the value of pollinators to agricultural production. Losey and Vaughan (2006) estimated that native North American pollinators, primarily bees, may be responsible for nearly US$ 3.07 billion of fruits and vegetables produced in the United States. Ricketts *et. al.* (2004) found that 7% of coffee production in Costa Rica (approximately US$ 60,000 annually per farm) came from the pollination services provided by wild pollinators. Pollination by wild bees increased yields by 20% from crops closer (≈ 1 km) to forest patches. They reported that coffee plants located closer to forest patches also showed lower incidence of "peaberries" (small, quality and quantity of the coffee yield. Nabhan and Buchmann (1997) report that U.S. alfalfa farmers avoided a 70% reduction in alfalfa yields by replacing declining honey bees with alfalfa leafcutter bees and native pollinators. If alternative pollinators had not been available, the lost production would have cost American consumers US$ 315 million annually. Southwick and Southwick (1992) estimated the annual economic benefit to American consumers from honeybee pollination of agricultural crops at US$ 1.6 billion to US$ 8.3 billion. This estimate was based on an assessment of the potential economic losses if honeybee services were reduced for 62 American crops. The low value assumes that wild pollinators could replace honeybees as pollinators of these crops; the high value assumes no other pollinators would be available. Therefore, this also provides some idea of the value of wild (primarily native) pollinators with respect to the crops examined in this study.

For natural communities, monetary value of pollination services is even more difficult to estimate. However, one might assess the (non-economic) value of pollinators to the conservation of rare species, maintenance of biodiversity, and ecosystems. For example, it may be possible to gain perspective on the non-economic value of pollinators by predicting which organisms might disappear with the decline or loss of certain pollinators by estimating the contribution of a particular pollinator to the existence of a rare plant, or by comparing the species composition and functioning otherwise similar ecosystems that differ in pollinator abundance.

In the Himalaya, honey bees have been an important component of mountain agriculture as they provided cash income, nutrition and medicine to the people through honey production as well as other bee products. There is now an increasing recognition of the role of honey bees in pollination. They also play hitherto unrecognized role in maintaining the vegetation cover: more pollination means more seed, more young plants and eventually more biomass, providing food and habitats for a wide range of wild creatures (Ahmad *et. al.,* 2004). Despite this, the population and diversity of native bees is declining in the region. Factors causing the decline include: habitat loss through land use changes, increasing monoculture and negative impacts of pesticides and herbicides. In addition, the well-intended introduction of the European honey bee, *Apis mellifera,* in the Himalaya has brought difficulties for indigenous bee species, partly because of competition for nectar in some areas, but more importantly through the introduction of different types of contagious bee diseases and harmful mites (Ahmad and Partap, 2000; Partap, 1999). These authors have reported that *A. cerana* has proved its efficiency in pollinating mountain crops and flora as compared to exotic *A. mellifera* and serving as an engine of biodiversity conservation and productivity enhancement. Moreover, early flowering crops of mountain areas (almonds, peaches, plums, cherries etc) are pollinated more efficiently by this bee species due to its ability to work in cooler climates and longer working hours.

Honey bees and other wild bees are among important pollinators for crop plants and fruit trees

Agriculture in the Hindu Kush-Himalayan region is in a stage of transition from traditional cereal-millet crop farming to high-value cash crops such as fruits and vegetables. This ongoing transformation from subsistence to cash crop farming poses a number of new challenges, including low production or crop failures due to inadequate pollination. This emerging problem has been documented in a series of field studies carried out by ICIMOD across the region (Ahmad and Partap, 2000; Partap, 1999, Pratap and Pratap, 2001). It appears that diversification of mountain farming to high-value cash crops is going to face through a major crisis due to pollination-related productivity failures. Findings suggest that decline in pollinator intensity presents a serious threat to agricultural

production and maintenance of biodiversity. The negative impact of declining pollinator intensity is visible in Himachal Pradesh of India, Pakistan, Afghanistan and China. In fact, the negative effects of modern inputs in agricultre on pollinators is one of the major causes of pollination failure and hence the observed declines in productivity. For example, apple cultivation in Himachal Pradesh in India, has resulted in a loss of agricultural biodiversity and a decline in natural insect pollinators. The studies carried out by ICIMOD reveal that declining apple productivity is a result of inadequate crop pollination (Pratap and Pratap, 2001). In this area, farmers are now compelled to rent colonies of honey bees for pollinating their apple orchards. At present, it is mostly the Department of Horticulture and a few private bee keepers that rent out bee colonies to apple farmers. The current rate for renting an *A. cerana* or *A. mellifera* colony for apple pollination is US$ 20 per colony (Ahmad *et. al.,* 2004). Only a few farmers keep their own colonies for pollination. A heavy demand for honey bees for pollination has been created, and there are not enough bee colonies to meet this demand. Hence, in the apple growing areas of Himachal Pradesh, there is a tremendous scope for entrepreneurial beekeeping for pollination. In other words this emerging phenomenon of pollination by hiring the bee colonies (otherwise conserving biodiversity) is a perfect example of PES.

Similar examples are emerging from other parts of the globe as well. The alteration of natural systems and the loss of pollinating species have caused a decrease in productivity of many crops. In Brazil, Paulo and Flavia (2004) reported that the farms near forest fragments had an increase of 14.6% in coffee production that can be related to the robust pollinating services provided by wild pollinators. In the highlands of Colombia rearing of native bumblebees for pollination of tomato and native fruits has been found beneficial for fruit quality and seed set. In Maxian County and Sichuan in China, farmers have resorted to hand pollination of their apples and pears, as there are not enough natural insect pollinators to ensure a proper fruit setting. Awareness about the use and function of honeybees is lacking, and the beekeepers in this area hesitate to let their bees into this fruit-producing valley because of the serious overuse of pesticides in apple orchards. In Pakistan, disappointed farmers are cutting down their apple trees and recently ICIMOD found evidence of cutting down almond orchards in the Bamiyan valley of Afghanistan due to low yields caused by insufficient pollination. In China, honey gathering communities have been sensitized to protect and conserve the nesting habitats of the wild bees, which provide them with additional income, and also contributing to the conservation of biodiversity (Ahmad *et. al.,* 2004).

Box 2.6.1: The Importance of Polliniser Trees (Adapted from the article "Declining apple production and worried Himalayan farmers: promotion of honeybees for pollination issues in mountain development 2001 by Uma Partap and Tej Partap).

In Himachal Pradesh in India, farmers used to plant many varieties of apples. However, due to the better market value farmers have been planting only Royal Delicious and uprooting other varieties. Royal Delicious is self-sterile and requires cross-pollination from other compatible varieties for fruit setting. Some farmers do not have even a single polliniser tree in their orchards. So, wherever the orchards have Royal Delicious only, there are serious pollination problems. Some farmers are now including "polliniser" trees in their orchards. These are grafted on to commercially premium varieties for fast results. Farmers have even devised short-term solutions to bridge the gap until the grafted branches or newly-planted polliniser trees begin flowering: Bunches of small flowering branches of the pollinisers called "bouquets" are put in plastic bags filled with water. These bouquets are hung from the branches of commercially premium varieties. This type of pollination method is locally referred to as "bouquet pollination". The large-scale use of plastic bags has increased the price of plastic bags in the local market from US$ 0.75 per kg to US$ 2.10 per kg.

Keeping bee hives in orchards ensure pollination of fruit trees besides providing honey and other bee products to local farmers

Uttarakhand Scenario

Studies on pollination are almost non-existent from the Uttarakhand Himalaya. However, honey bees rearing has been a traditional practice in many households of this region. It has been observed that in the high altitude areas where forest cover is relatively higher, people manage higher number of bee hives in their houses and court yards implying role of forests in maintaining higher honey bee colonies. For example, in Ukhimath area of district Rudraprayag (Garhwal) most of the villages surrounding the dense oak-rhododendron forests and closer to the alpine grasslands a permanent provision for bee-hives in the houses is kept. Honey extracted from these beehives is a supplementary source of income for the people. On the contrary, such behives have not been noticed in areas where forests are absent in the surroundings. While data for Uttarakhand is not available; an Australian study for beekeeping estimated gross value of pollination to the country to be over US$ 1 billion per annum. This is worth over 30 times more than the value of honey produced in Australia (26,000 t annually worth US$ 37 million). This fact is of critical importance to Uttarakhand with a predominantly agricultural and forest based economy. The value to the agricultural and horticultural economy must also be seen in the context of the `organic' positioning that the state wishes to promote. Bees have a beneficial effect in reducing the need for chemical pesticides by consuming pollen that attracts various pests. There are no accurate estimates of honey production in Uttarakhand. Appropriate Technology Institute at Ukhimath, which is one of the biggest players in the region, sells approximately 70 t honey annually much of it collected from Rudraprayag and Chamoli districts. Much of the honey in the district is consumed locally or sold directly to tourists, as the prices for direct sale (Rs 100-150 litre^{-1}) is typically much higher than prices when sold to institutions that brand and further market the honey (Rs 30-70 litre^{-1}). The price of certified organic honey is however significantly higher and can increase farmers income. Overall, Himalayan honey can fetch higher prices than honey produced in the plains because a buyer is likely to pay a premium for honey produced in what is considered to be a relatively pristine and pure environment.

Conclusion/Recommendations

There is a dearth of comprehensive list of pollinators, knowledge on major plant species they pollinate, and their forest habitats in Uttarakhand. Impacts of various developmental activities that affect forest ecosystems on different pollinators have to be evaluated. Lack of research on how large scale biological invasion such as forest areas invaded by *Lantana camara, Eupatorium, Parthenium* etc. affects populations of various pollinators. Information is also lacking on the total quantity and quality of honey produced in Uttarakhand that could be used as a surrogate indicator of pollination service as well as of species richness/biodiversity in forests and crop fields foraged by honey bees.

Chapter 3

Valuation of Forest Ecosystem Services in Uttarakhand Himalaya

Forests not only provide various goods like timber, fuel wood, pulpwood, fodder, fiber grass and NTFPs; and support industrial and commercial activities; but also life supporting ecosystem services for the all round development of human kind. Forests exercise control over the wealth of adjoining land use systems such as agriculture and animal husbandry and also the wealth of urban areas through provisioning of various ESs. Degradation of forests results into impoverished agriculture, horticulture, livestock population and thus triggers migration of dependent communities to urban areas where they end up in low paid, unsecured informal sector jobs (Verma, 2000). As the loss of a forest provision is fundamentally economic in nature, its conservation needs to be addressed in economic terms. For forests to be conserved, they need to be perceived as being more valuable than the usual, standard utilities they provide (Verma, 2005).

Provision of Ecosystem Services from Forests

Traditionally, the forest resources are taken as "free gifts of nature". The neoclassical economists introduced "natural capital" with "man- made capital" and recognized the changes in natural capital such as depletion, degradation or regeneration as a result of human interference in assessing the value of resources. Unlike man made capital, natural capital is strongly linked with the habitat and ecology and provides multiple and interrelated benefits for human wellbeing. These ESs categorized as provisioning, regulating, cultural, and supportive are very much linked to each other like the nutrient cycling services of forests promote the growth of forests itself which in turn provides many goods hence the forests is also termed as the natural capital (Munasinghe and McNeely, 1994). Though the man-made capital is typically unidirectional and also has established markets, most of the services provided by forests do not have markets. As a result, the intangible services of forests such as recharging of ground water, regulation of stream flows, flood control, prevention of soil erosion, nutrient cycling, water purification, carbon storage, pollution control, micro-climatic functions, biodiversity, evolutionary processes, recreational, spiritual and aesthetic values are grossly underestimated or ignored during development planning (Box 3.1). However, the situation has changed considerably post Rio Earth Summit due to increased awareness on the value of forests as a natural capital.

Box 3.1: Total Economic Value and Natural Resource Accounting

The Economic value expresses the degree to which a good or service satisfies individual preferences. Many goods and services are exchanged in a market, which automatically reveals their value. Whereas others may not enter into exchange mechanisms but are used for self consumption such as fodder, fuel wood, many NTFPs etc. Besides all the material goods, many ecological benefits such as soil and water conservation, pollination services, flood control, sediment control, Carbon sequestration, soil carbon pool, ecological succession also do not make part of the market mechanism. The market, however, is capable of revealing only one component of the total economic value. On account of lack of (TEV) estimate for ESs, the current System of National Accounts (SNA) of the country reflects only the marketed value of the ESs and the whole array of ecological services do not find any place in the current calculus of National Accounting and GDP (Gross Domestic Product) estimate which is a gross underestimation of their contribution in the national economy. The TEV is a prerequisite to reflect the worth of such services.

To estimate these values wide variety of valuation techniques are used comprising of both monetary (cardinal and ordinal) and non monetary techniques. There are three generally accepted approaches to estimating monetary values of ESs. It comprises of (i) Market Prices where either Direct Market Price (Revealed Willingness to Pay) approach for products, such as fish or timber, that are traded in markets or clean water used as inputs in production or Indirect Market Price (Hidden Price) to capture values of services, like scenic beauty or many recreational experiences, may not be directly bought and sold in markets are estimated. The production function approach is used to reveal the values of functions like ecological succession. In such cases indirect valuation techniques like the hedonic pricing is used to estimate economic values for ESs that directly affect market prices e.g. to value environmental amenities that affect the price of residential properties or the Travel Cost Method to estimate economic use values associated with ecosystems or sites that are used for recreation. The (ii) approach to the value is the Circumstantial Evidence (Imputed Willingness to Pay) where the value of some ESs can be measured by estimating what people are willing to pay, or the cost of actions they are willing to take, to avoid the adverse effects that would occur if these services were lost, or to replace the lost services. For example, forests often provide protection from flood waters. The amount that people and institutions pay to avoid flood damage in areas similar to those protected by the forests can be used to estimate willingness to pay for the flood protection services of the forests. Another example could be carbon credit markets for Carbon sequestration. These methods estimate damage cost avoided, replacement cost, and substitute costs. Another approach is (iii) Surveys (Expressed Willingness to Pay) where surveys can be used to ask people directly what they are willing to pay based on a hypothetical scenario. In this context the contingent valuation method (CVM) is used where the people are asked to state their willingness to pay, contingent on a specific hypothetical scenario and description of the environmental service. The (iv) **Benefits Transfer** Method (Reusing Economic Studies) is used for a resource at a particular site for estimation of values at another site. By making adjustments for per capita GDP and price level the value of the researched site is transferred to the new site.

Natural Resource Accounting (NRA) is part of the system of integrated environmental and economic accounting, which results in an environmentally adjusted GDP by internalizing the economic values of ESs provided by various ecosystems. Natural resource accounting takes into account the direct and indirect costs and benefits associated with natural resources and environment, both used and not used in the production process as well as those which are not yet used. Such an accounting involves the calculation of stock and reserves of natural resources including their changes.

Forest Utilization and Production in Uttarakhand

Of the total forest area under the SFD (24413.2 km^2) only 62.23% area is exploitable. Rest of the area is inaccessible, barren and degraded or lie as blank area. The variation in exploitable area in the landscape has created great diversity of flora and fauna, and consequently, resources. These resources have been further augmented through plantation activities of the State Forest Department. The resources pertaining to forest areas of Uttarakhand are briefly mentioned below.

a. **Timber resources:** The plains have plantations raised for commercial use. These include teak, sal, eucalyptus, poplar etc. Hills too provide timber from conifers like deodar (*Cedrus deodara*) and chir pine (*Pinus roxburghii*).

b. **Non Timber Forest Produce:** These include resin from chir pine, bamboos, MAPs, wild edibles, fuel and fodder etc for use by local people and related industries.

c. **Minerals, Stone, Sand:** These are extracted from riverbeds when the rivers spread-out on reaching the plains. The extraction also carries out the function of "river training" i.e. keeping the river bed deeper, thus preventing floods.

d. **Aesthetic Values and Tourism Resources:** The forests provide the aesthetic value and structural resources that create ecotourism opportunities for the State. In fact, most of the tourism in the State relates to Nature/forest areas and even pilgrims benefit from it. The local communities are being involved in Eco-tourism activities as Community Based Tourism (CBT) has been introduced as a means of employment and income generation for the local communities in few of the interior areas by creating home stay and camping sites, nature trails, village tourism etc. A Centre for Eco-tourism was set up in 2003 at Chunakhan near Corbett Tiger Reserve. Attempts are also being made towards controlled and regulated tourism started in a 9 km stretch of Nandadevi Biosphere Reserve through Public-Private-Partnership (PPP) in management of Forests Rest Houses. Angling has been identified as a new thrust area in the field of Eco-tourism.

Current Contribution of Forest to the Gross Domestic Product (GDP) of the Uttarakhand State

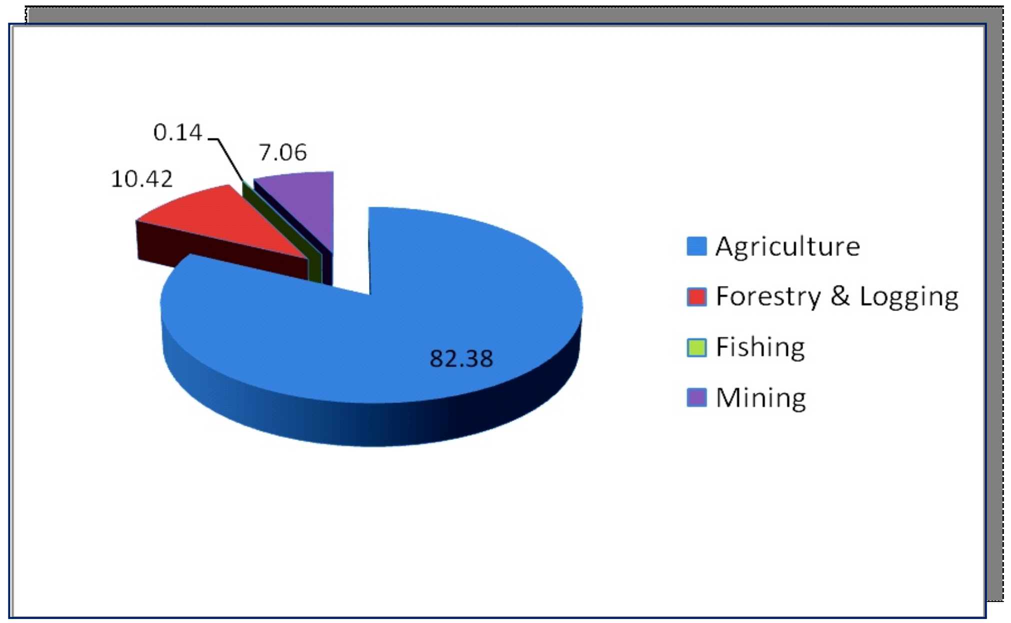
Despite making considerable contribution in Uttarakhand's economic and ecological security, the forests of the state do not get proper recognition of their contribution in the State Domestic Product (SDP). The present SNA is primarily focused on growth rates of GDP and it fails to capture several important elements of natural wealth both qualitative and quantitative. The value of forest reflected in the India's SNA represents less than 10% of the real value of the forests. In 2002-03, forests contributed Rs. 270,130 million to India's GDP at the current prices, which was 1.2% of the GDP. The contribution of forest to India's GDP has varied from 1.0 to 1.5 % over the nine year period from 1993-94 to 2002-03. Similarly, the contribution of forestry and logging to India's Net Domestic Product (NDP) also varied from 1.3% to 1.6% during the same period. The forests of the state of Uttarakhand also confronts such ironic scenario where despite being provider of a wide array of ESs its contribution reflected in the SDP is only 3.50% as only few goods and services from forest of Uttarakhand are marketed and thus accounted in the current calculus of SDP of the state(Table 3.1).

Table 3.1: Share of Different Sectors in Net Domestic Output of Uttarakhand at current prices, 2003-04

S.N	Sector	Product (Rs. in Million)	% Share
A	PRIMARY SECTOR	49070.7	33.64
1	Agriculture	40,428.4	27.71
2	Forestry and Logging	5,109.6	3.50
3	Fishing	68.9	0.05
4	Mining	3,463.8	2.37
B	SECONDARY SECTOR	32,419	22.22
5	Manufacturing		
	a) Registered	7,846.1	5.38
	b) Unregistered	2,630.8	1.80
6	Construction	20,728.1	14.21
7	Electricity, Gas and Water Supply	1,214	0.88
C	TERTIARY SECTOR	64,401.2	44.14
8	Transport, Storage and Communication	7,257.4	4.97
9	Trade, Hotels and Restaurants	10,626.7	7.28
10	Banking and Insurance	10,495.1	7.19
11	Real Estate, Ownership of Dwelling and Business Services	9,335.7	6.40
12	Public Administration	9,680.1	6.64
13	Other Services	17,006.2	11.66
	Total (A+B+C)	**145,890.9**	**100.00**

The Annual Plan 2006-07 of Uttarakhand recognizes that "though the recorded forest area in Uttarakhand is 64.8% with vegetation cover 43.5%, maintenance of this forest cover is important not only for Uttarakhand but for the whole country.

Fig. 3.1: Percentage Share of Different Sub Sectors in Primary Sectors' Net Domestic Output of Uttarakhand at Current Prices, 2003-04



It further states that the state government has actively involved village communities in protection and management of the forests. Thus, besides the institutions of Van Panchayats (VPs), the newly created institution of Joint Forest Management (JFM) has provided the institutional framework for this interaction. The Protected Areas (PAs) both formal and informal network constitutes about 18.69% of the forest area and a similar protective role is played by the Eco Development Committees in and around the PAs. To encourage cultivation of Bamboo and Jatropha a separate Board has been created and plantation on mass scale has been introduced from the year 2004-05. But to carry out all such activities the sector gets only 6.35% of total outlay annually as against 27% outlay to the agriculture (2006-07). Though looking to the usual *quid pro quo* mechanism of allocation of funds for contribution to SDP in Indian planning process, it looks though double of the contribution but looking to the geographical extent of forest area of 65% the allocation is highly disproportionate. Thus it's high time to recognize value and account the contribution of ESs from Uttarakhand forests in the SDP estimation framework and also develop incentive based mechanisms for the communities conserving the forests of the state specially the 12,064 VPs of the state currently managing 523,289 ha area of forest.

Economic Valuation Studies for India's Forests

Several attempts have been made in India recently through case study approach to estimate economic value of various intangible benefits of forests like eco-tourism, recreation, water supply, watershed value, carbon storage and biodiversity. For the first time in the country Total Economic Valuation (TEV) and Accounting attempted by Verma (2000) for the state of Himachal Pradesh (HP). As the time was short the study used the findings of the specific case studies and projects conducted in the state of HP to estimate the TEV of forest resources of HP. The study found that except for some contribution by way of salvage removals, Timber Drawing Rights (TDRs) and NTFPs, all values generated form forests of HP go totally unaccounted despite their high monetary worth. As per the study's estimate, the watershed values contribute the most (69%) followed by Carbon sink values (16%) in the SDP from forest sector. When TEV in terms of Rupees per ha contribution of forests is calculated for the legal forest area (36,986 km^2) it stands at Rs. 0.3 million ha^{-1} whereas for the actual forest cover (14,346 km^2) it approximates to Rs. 0.74 million ha^{-1}. If we take the contribution only in terms of intangibles, the per hectare contribution stands Rs. 0.69 million as against Rs. 53,000 ha^{-1} for direct values for actual forest cover and Rs. 0.3 million as against Rs. 21,000 for direct values for legal forests. Thus the total contribution of forests amounts to Rs. 1066.64 billion but what is accounted is only Rs. 410 million by way of revenue realized by the SFD. The total economic value so generated is compared with the value of the growing stock, total expenditure incurred on forests (Annual Budget) and the revenue realized. It was further found that total economic value is 2.61 times the value of the growing stock, 980 times the total expenditure incurred in the forestry sector of HP and 2607 times the revenue realized by the forests annually. This comparison proves gross underestimation of forestry sector's contribution in the economy of the state. When the Gross State Domestic Product (GSDP) of the state is corrected for total economic value calculated through the current study, the contribution of forestry sector increases from 5.26% of GSDP to 92.40% of GSDP.

Note: *The major strength of the study was that it was the very first work in India at the state level to estimate the TEV of state's forest which helped the state in implementing the one time ecological cess in case of converting forest area for non forestry purpose. The cess so collected would to go to Compensatory Afforestation Fund Management and Planning Authority (CAMPA) fund for undertaking the mandatory activities. The major limitation of the study was its secondary studies based data.*

Recommended Framework of Valuing Forest Ecosystem Services in India

The value added generated by forest goods and services is a portion of the extraction cost, measured as output minus all intermediate costs of production. The *in situ* value is the amount that someone will be willing to pay to rent the forest in order to have access to the non-market forest products. If non-market forest products were to be included in forest asset accounts, it is the *in situ* value that would be used. The major area of concern is the valuation of intangible benefits from forests.

Many valuable ESs as mentioned above are finally gaining some attention. Today governments, companies, and citizens are increasingly recognizing the value of the wide range of services forest ecosystems provide (Michael, 2002). A number of independent studies have been conducted using various techniques to estimate economic values of forests which have greatly helped in bringing these environmental considerations into economic planning as also mentioned in the previous section for the state of HP.

Experiencing the problems in estimation of economic values from forests due to lack of any standardized methodology, Verma *et.al.* (2003-2006) have proposed a framework based on the methodology developed and data generated in project titled "Natural Resource Accounting (NRA) for the States of Madhya Pradesh and Himachal Pradesh" sponsored by the Central Statistical Organization (CSO), Ministry of Statistics and Programme Implementation (MOSPI), Government of India (GOI) conducted at the Indian Institute of Forest Management (IIFM), Bhopal for estimation of annual flow values from forests (Verma, 2006). The methodology has also been recommended to the Institute of Economic Growth (IEG), Delhi for the Ministry of Environment and Forest (MoEF) sponsored Project on "Estimating Economic Value of Forests" (2006), findings of which have been used by the Expert Group Report, constituted by the Hon'ble Supreme Court of India in 2005, to suggest suitable Net Present Value (NPV) of forests and costs estimates suggested by the Empowered Committee's Report on NPV at IEG, New Delhi 2006.

Table 3.2: Estimation of NPV of Forest Resources of India for its Use in Forest Resource Accounting System (Continued)

Ecosystem Service	Annual Value (Benefit)	Annual Costs
1.Timber - logging, TDRs/Nistar and Salvage	Long run Stumpage value approach or Stumpage price of mature timber and salvaged timber	Costs of production (departmental), extraction and transport
2.Fuel wood	Total value of fuel wood collected in a normal year = No. of rural households collecting fuel wood from forest in last 365 days x Average value of collection per collecting household. (the value to be used is the relevant price in the nearest local market)	Cost of collecting fuel wood = (No. of rural households) X (Total annual time cost of collection per household valued at 15% of average agricultural wage rate).
3.Fodder	Total value of fodder collected in a normal year = No. of rural households collecting x fodder from forest in last 365 days x Average value of collection per collecting household. (the value to be used is the relevant price in the nearest local market)	Cost of collecting fodder = (No. of rural households) X (Total annual time cost of collection per household valued at 15% of average agricultural wage rate).
Grazing	Total no. of livestock grazing in state forest x total fodder receipt	Management cost

Table 3.2: Estimation of NPV of Forest Resources of India for its Use in Forest Resource Accounting System (Continued)

Ecosystem Service	Annual Value (Benefit)	Annual Costs
4.Non Timber Forest Products (including grass) - extraction method	Per hectare value of NTFP collected in each circle – Value of NTFP in each circle / Net forest area in each circle. Value of NTFP in each circle = Value of NTFP collected in a normal year per household x No. of rural households (the value to be used is the relevant price in the nearest local market) or cost function to get actual market value of medicinal herbs based on the royalty or permit value collected.	Cost of collecting NTFP = (No. of rural households) X (Total annual time cost of collection per household valued at 15% of average agricultural wage rate).
Consumption method	Household survey using Village input-output model	Wage rate for labour inputs
5.Carbon Sequestration	Value of carbon stock = carbon content x market rate of carbon. Carbon Content= Biomass x IPCC-GPG default value1. Biomass = Growing stock x Conversion factor	No. direct costs.
6.Ecotourism/Landscape beauty	Per ha Value of Eco-tourism in each circle = Total value of Eco-tourism in each circle / Net forest area in each circle. Value of Eco-tourism dependent on forest ecosystems = No. of people visiting different circles per year mainly due to natural beauty X average expenditure incurred per person	Costs incurred by the Forest Department in the maintenance, preservation and development of National Parks and Wildlife Sanctuaries. The per hectare cost were calculated to arrive at costs for each circle. See Step 6 for common departmental costs.
7. Watershed functions - soil building, nutrient movement, Hydrological and climate regulations, floodplain benefits	Value per hectare for specific watershed function based on secondary site specific studies.	As per site specific secondary studies.
8. Biodiversity/ Bio-prospeting		
(i) Actual value approach	(i) Potential value of drugs that can be obtained from the bio-diversity present in forests	Cost of collection
(ii) Option value approach	(ii) insurance premium paid to ensure the supply of an asset, the availability of which otherwise would be uncertain	R and D costs

Supreme Court Judgment dated 26th September 2005, case No. Writ Petition (Civil) 202 of 1995 directed to set up an expert group to suggest suitable NPV. The following issues were examined by the expert group. (i) To identify the definite parameters (scientific, bio-metric and social) on the basis of which categories of values of forest should be estimated; (ii) To formulate a practical methodology applicable to different biographical zones of India for estimation of value in monetary terms in respect of each of the above categories of forest values ;(iii) To illustratively apply this methodology to obtain actual numerical value for different forest types for each biographical zone of the country; (iv)To determine on the basis of established principles of finance , who should pay the cost of restoration and / or compensation with respect to which category of values of forest and (v) which project deserves to be to whom exempted from Payment of NPV.

Note: (1) The value for fodder, fuel wood, NTFP are based on the report of the NSSO 54th round Survey on Common Property resources in India, (2) Annual values in column 2 for items 1-8 are calculated as per methodology developed by Verma *et.al.* (2003-2006) at the IIFM, Bhopal in the Project on ' Natural Resource Accounting of Land and Forest excluding mining) in the States of M.P. and H.P. sponsored by the CSO of the Ministry of Statistic and Program Implementation, GOI. (4) Annual Costs in column 3 were calculated for items1-7 except for TDRs/Nistar and Salvage, Grazing and household consumption of NTFPs in Empowered Committee's

Report on NPV, New Delhi 2006.

Estimates of Monetary Value of Forest Ecosystem in Uttarakhand under Different Valuation Scenarios

When decision to alter natural forest ecosystems, often little thought is given to the consequences that change may have on forest ecosystem services or to the ultimate cost of losing those services. This oversight stems from our incomplete knowledge about how changes in ecosystems affect the level of services that the systems provide and out inadequate understanding of the roles played be seemingly trivial ecosystem components.

Perhaps the most significant factor is that few ecosystem services have clearly established monetary values but most of them have not. And this can have a strong impact, considering that many decisions are based on monetary estimates of ecosystem services.

The following sub section is an attempt to present values of ecosystem services from Uttarakhand forest estimated either through various studies and methodological scenarios or by using estimates of other studies to arrive at approximate estimate for the Uttarakhand forest. The study only provides indicative values which need to be further refined using primary level data which could be generated using appropriate valuation technique as stated in the above section. Thus instead of extrapolation, it provides approximate values, strengthen, impacts and limitations of each study and suggests techniques of fulfilling information gaps such that realistic picture of contribution of Uttarakhand forests at various spatial levels can be arrived at. Such valuation process shall eventually help in adjusting the SDP of the state and would help the state to make a claim for compensation for keeping such large area under forests and to get proper award of funds for sustainable management of its forests.

Scenario I: Values of Ecosystem Services of the Forests of Uttarakhand Based on Estimates of Costanza *et. al.* (1997) Framework

Costanza *et. al.* (1997) identified 17 specific goods and services provided by ecosystems: gas regulation, water regulation, water supply, erosion control and sediment retention, soil formation, nutrient cycling, waste treatment, pollination, biological control, refugia, food production, raw materials, genetic resources, recreation and cultural services. The study provides a revealing but rough estimate of the magnitude of ecosystem service values on a global scale, and the reported values can serve as a basis for estimates relevant to specific regions or ecosystems. The study provided the estimates of forest ecosystem values for tropical, temperate and boreal forests of the world.

Table 3.3: Annual Value of Various Forest Ecosystem Services of Uttarakhand (Values are calculated from various parameters given for forests in Costanza *et. al.*, 1997).

Ecosystem service	Value in US$ ha/ yr (US$ 1 = Rs. 44.5)
Climatic regulation	167.6
Disturbance regulation	2.3
Water regulation and water supply	5.2
Erosion control	114.6
Soil formation	11.6
Nutrient cycling	429.6
Waste treatment	102.7
Biological control	2.3
Food production	50.7
Raw material	164.0
Genetic resource	18.5
Recreation	78.6
Cultural	2.3
TOTAL	1150

Costanza *et al.* (1997) synthesized previous studies based on a wide variety of methods of environmental economics and used their own wherever necessary. In order to make estimations of total value of ESs they estimated the total global extents of ecosystems and classified them into 16 primary categories such as coastal areas, open areas, tropical and temperate forests and grasslands. Valuation of each type of ecosystem and each of ecosystems service was done separately. Though the figures of Costanza *et. al.* (1997) are global but from them one could draw some conclusions for the Himalayan area. Himalayan forests are closer to temperate forests as far as species richness is concerned, however, in terms of ecosystem functioning these resemble to tropical forests (Zobel and Singh, 1997). Since the latter factor is more important in relation to ESs, for Himalayan forests taking the mid-point (Table 3.3) values of ESs estimated for tropical forests (US$ 2007 ha^{-1} yr^{-1}) and temperate/boreal forests (US$ 302 ha^{-1} yr^{-1} it was considered safe to take a conservative value to generate indicative value for various forest ESs of Uttarakhand (Singh, 2007). As shown in Table 3.3, with an average value of about US$ 1150 ha^{-1} yr^{-1} the total value of the ESs from the forests of Uttarakhand (area 2,352,700 ha, P.S. Roy and P. Joshi, unpublished data as quoted in Singh, 2007) is approximately US$ 2.4 billion yr^{-1} or Rs. 107 billion yr^{-1}.

Note: *The major strength of this estimate is that it provides the TEV of state's forest in terms of the very first study taken at the International level to value various intangible ecosystem services which led to a movement towards estimation of such values using primary data all over the world.*

Scenario II: Values of Ecosystem Services of Forests of Uttarakhand Based on Estimates as per Forest Disability Index

The finance division of the Planning Commission worked out an interesting index called as the forest disability index based on the reasoning that on account of keeping large area under forest, there has been loss of Rs. 1,124,906 per km^2 net revenue from forest conservation in relation to the agricultural sector productivity(Table 3.4). Taking the value further to the overall loss, there has been total loss of Rs. 16,210 million annually to the state on account of forest conservation. The current contribution of the forest sector to the SDP of Uttarakhand is only Rs. 5,110 million annually. If we further subtract this contribution from the value at par with agriculture i.e. Rs. 16,210 million the final annual loss to the forestry sector comes to Rs. 11,100 million. While sacrificing this revenue the sector provides considerable amount of watershed services specially water to the downstream regions but no compensation is being provided to the state for keeping aside such large tract under forestry and not taking agricultural or industrial development.

Table 3.4: Computation of Forest Cost Disability Index for Uttarakhand vis-à-vis Other States having large Geographical Areas under Forest

S.No.	Items	Madhya Pradesh	Himachal Pradesh	Uttarakhand
1.	Total Area of the state	308,245	55,673	53,483
2.	Area under Forest (km^2)	95,221	35,407	34,650
3.	Forest as %age of total Geographical Area of the State	30.90	63.60	64.79
4.	Per Unit cost of maintenance(Rs./km^2)	41,856	41,856	41,856
5.	Total Cost of maintenance (Million Rupees)	3,976	1,482	1,450
6.	NSDP from Agriculture (Million Rupees)	152,877	27,487	40,428
7.	Agriculture Income Less Forest Cost (Million Rupees) (6-5)	148,901	26,005	38,978
8.	Revenue Loss (Rs./km^2) (7/2)	1,563,741	734,459	1,124,906

Extrapolating the revenue loss per sq. km. to the area under forest in the state, the loss incurred would amount to Rs. 16,210 million annually. The values so generated though arrived at using a crude method of substitution but nevertheless be used for assessing of compensation to the VPs who have been managing forest for almost last 75 years, incur considerable costs in terms of their labour and time inputs but have never been given any incentives for sustainable managing these forests. If some compensation is received by the SFD based on the above formula should be shared with the VPs in proportion to the protected and reserved forests maintained by them.

Note: *The disability index though provided a handy value for the forested states of the country to make a case to the planning commission based on sacrificing agricultural and industrial production for conserving forest and helped in increased allocation of central funds (Rs. 350 million for five years). But the major limitation of the study was its assumption that the entire forest area irrespective of its slopes, terrain, soil could be cultivated which may not be necessarily the case in the Himalaya. Further it assumed that the desired number of human labor would be available to undertake agricultural operations. Above all the cost of environmental damage due to agriculture would be huge which again did not find any place in the quick estimates. Possibly the net value of agriculture may come negative if all externalities and costs of reclaiming the forest land for agriculture are considered. Thus this estimation approach has to internalize many such factors to reflect the true value of forest disability.*

Scenario III: Values of Ecosystem Services of Forests of Uttarakhand Based on Estimates of P.J. van der Meer *et. al., 2006* study on Goods and Services from Cultivated Forests in Garhwal Region, Uttarakhand, India

The following section presents the provisional findings of the work (Vander Meer *et. al*, 2006) as the study was conducted in Garhwal region having population of 3.5 million (151 persons km^{-2}) with forest and vegetation of Low zone: Sal trees (*Shorea robusta*), Middle zone: Chir pine (*Pinus roxburghii*), High zone: Oak (*Quercus leucotricophora*) and Deodar (*Cedrus deodara*). Four villages in three ecological zones were included (low zone: 600-1000m), middle zone (1000-1600m) and high zone (>1600m). The study used the typical Millennium Ecosystem Assessment, 2005 framework to describe various ESs of the region. The study found heavy dependence of people on forest resources as 67.6% household requirement for provisioning services like food products, raw materials (timber, fiber, baskets), energy (fuel wood), cattle related products (fodder, cattle-bed), agricultural-related products (manure and others), cultivation (grazing) are met through forest of the region. It also finds that the 75% of the annual income of the people comes from the sale of marketable products from forests.

The study through ranking technique obtained the value of information services like aesthetic (3^{rd} rank), recreation (4^{th} rank), cultural heritage and identity (1^{st} rank), inspiration (5^{th} rank), education (4^{th} rank) and spiritual and religious (2^{nd} rank). These were in turn considered in the context of ecological value (in giving uniqueness/ rarity and renewability value), socio-cultural value (in giving health (therapeutic) and heritage value) and economic value (as attraction for forest nature-based tourism). The regulating service covered in the surveyed villages as per their average rank were local climate regulation (1) soil quality maintenance (2) water flow regulation (3) water quality maintenance (4) natural hazard regulation (5) air quality regulation (6) erosion control (7) biological control (8). The regulating service from surveyed villages were also analyzed as per importance of landscape where forest land was ranked first in all regulating services followed by community forests. The total economic value of these services ranged from Rs. 9,200 $household^{-1}$ yr^{-1} for water quality maintenance, Rs. 4,300 $household^{-1}$ yr^{-1} each for erosion control, soil quality maintenance, natural hazard regulation, air quality regulation, local climate regulation, biological control, to Rs. 4,100 household^{-1} yr^{-1} for air quality regulation.

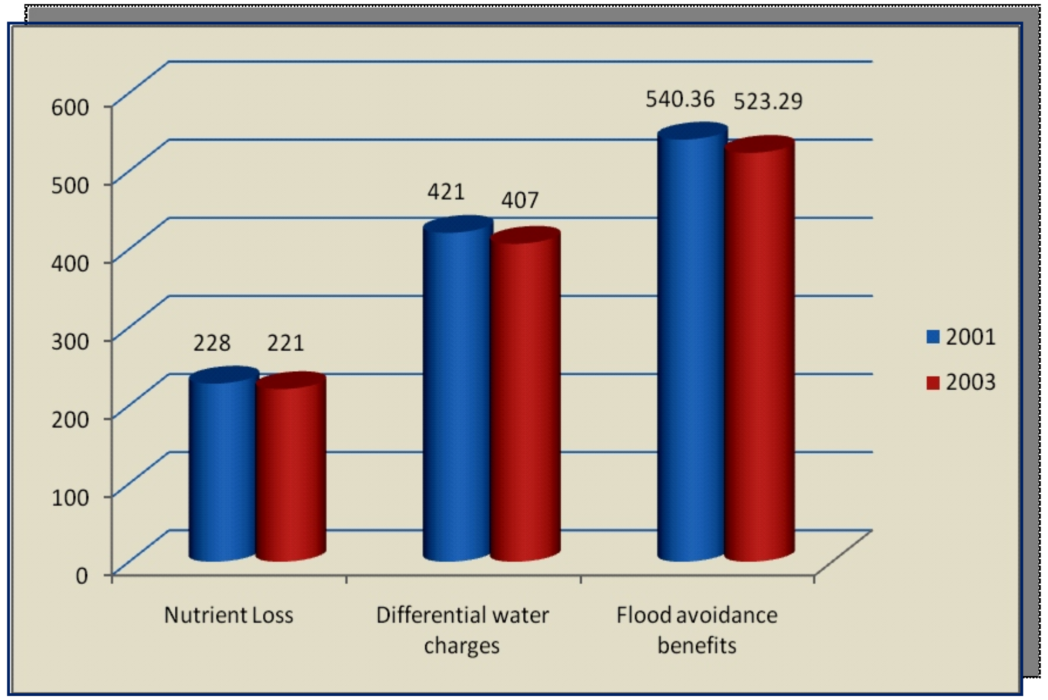
The study also indicated that the state and community forests of Uttarakhand are most important landscape units for provisioning and regulating functions in relation to other land uses specially agricultural lands, grasslands, river and streams, fallow land and the villages. Less-developed villages are more dependent on provisioning services from forests than more developed villages and economic value provisioning and regulating service very high (75% - 100% of average annual income). Though it collected qualitative data for information services but found them difficult to value economically. The households level TEV could be extrapolated for the rural household population to estimate the benefits derived from Uttarakhand forests.

NOTE: *This was the most recent study based on primary values for representative villages from low, middle and high regions of Uttarakhand based on the Millennium Ecosystem Assessment Classification of Ecosystem Services. The major limitation of the study was small size of its sample and short span of data collection which did not reflect the seasonal variations.*

Scenario IV: Values of Ecosystem Services of forests of Uttarakhand Based on Estimates of the Green Accounting for Indian States and Union Territories Project (GAISP) 2004-06

The Green Accounting for Indian States and Union Territories Project (GIST) has conducted studies on forest ESs using the available secondary data and attempted to adjust the national account using the improved estimates for forest values. The GIST study component of ecological services of India's forest estimated soil loss prevented by forest of India wherein for the dense forest of 1.90 million ha in Uttarakhand the soil loss prevented was 23.38 million t in the year 2001 and 22.64 million t in 2003. Nutrients of run off were Nitrogen (2.32 mg g^{-1}), Phosphorus (0.44 mg g^{-1}), Potassium (8.25 mg g^{-1}) and organic carbon (22.5 mg g^{-1}). For N, P, K, organic matter the nutrient loss for Uttarakhand was estimated as 54.24, 1.03, 192.88, 526.03 million kg, respectively, for the above mentioned nutrients in 2001, whereas the figures stood at 52.53, 1.00, 186.79 and considerable increase of organic matter run off to 5094.14 kg in 2003-04. The economic value of nutrient loss was estimated at total Rs. 2,280 million in 2001-02 and Rs. 2210 million in 2003. Thus, the change in economic value over 2003 -2001 for nutrient loss in soil erosion prevented by dense forest was estimated as -72.1 million rupees. Further the economic value of differential water charge due to dense forest only was estimated at Rs. 122 million in 2001 and Rs. 118 million in 2003 in Uttarakhand state. The flood avoidance benefits for dense forest area was estimated at Rs. 5,404 million in 2001 and Rs. 5,233 million for effective avoided flood damage. Thus totaling the valuing the nutrient loss, water recharge and flood benefits Rs. 11,885 million (11.88 billion) worth of ESs were provided by Uttarakhand forest in 2001 with annuity value of Rs. 297,124 million (297.12 billion). The total value stood at Rs. 11,509.5 million annually for these services and Rs. 287,739.7 million (287.74 billion) for annuity value in 2003. The change in annuity value for ecological services was Rs. 9,305 million in the state. Adjusting these figures to the net domestic product there was a decline of 1.79% in the value i.e. the ESDP was 98% of NSDP.

Fig. 3.2: Diagrammatic Representation of Forest Ecosystem Services from Uttarakhand Forest as Estimated under GIST Study (Annual In Rs. Crores; Rs 10 Million = 1 crore)



Another component of GIST project estimated the biodiversity value of Indian forest using data of National Parks in the state and generated net consumer surplus estimates from ecotourism in Uttar Pradesh and Uttarakhand states. It further worked out the marginal willingness to pay by the pharmaceutical companies for bioprospecting for the state of Uttar Pradesh.

NOTE: *The study gave a good comparative estimate of various states based on secondary data and showed how the existing information can be used to influence the policy. The major limitation of the study was its coverage of only few ecosystem services and lack of standardized estimation methodology.*

Scenario V: Values of Ecosystem Services from forest of Uttarakhand Based on Estimates of the project on Natural Resource Accounting (NRA) of Land and Forest (excluding mining) in the states of Madhya Pradesh (MP) and HP by IIFM for the Central Statistical Organisation, MOSPI, GOI (2003-06)

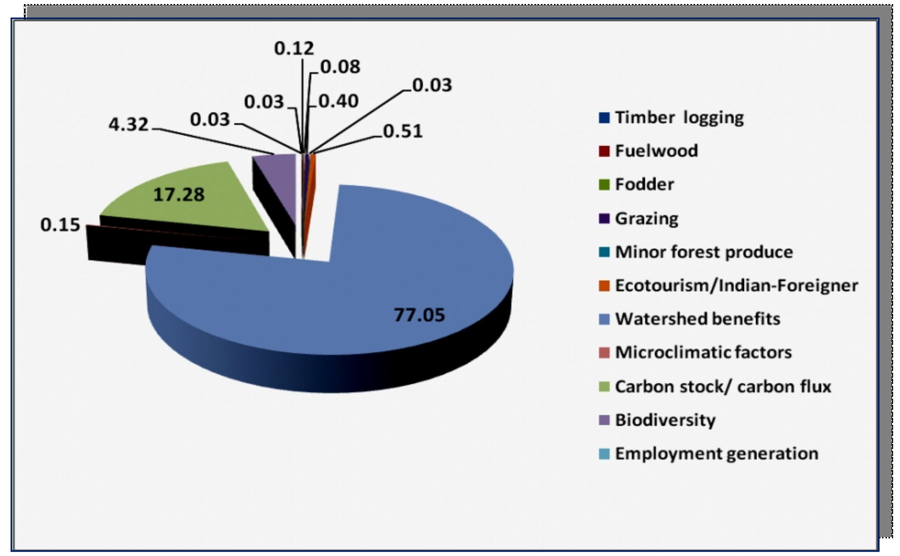
The proposed framework is based on the methodology developed and data generated in NRA Project of CSO at IIFM by Verma *et. al.* (2003-2006) for annual values from forests from the states of MP and HP. The state of HP and state of Uttarakhand nearly have same forest area i.e. 37,033 km^2 and 34,662 km^2 with forest and tree cover on 14,844 km^2 and 25,036 km^2 respectively. Thus the due to vegetative and location similarity, the per hectare values for ecosystem services generated under IIFM-CSO project already explained before. The values for ESs from Uttarakhand forest can be seen in the following table that the Uttarakhand forests provide whopping sum of Rs. 1,247,610 million (1247.610 billion) through watershed values followed by the Rs. 278,150 million (278.150 billion) from carbon sequestration function and total indirect benefits worth Rs. 173,120 million (173.120 billion) annually. The state provides Rs. 1,619,210 million (1619.21 billion) worth of ESs annually whereas the recorded value in the current system of SDP is only Rs.5,109.6 million in 2003-04, which is just 0.31% of the actual provisioning of various services.

Table 3.5: Annual Value of Ecosystem Service in Uttarakhand under the Scenario of IIFM-CSO (2005) Study for Himachal Pradesh

S.No.	Ecosystem Service	Per ha value of forest and tree cover area in HP (In Rs.)	Extrapolated value of forest and tree cover area in Uttarakhand (2503600 ha) - In Rs.
I. Direct Benefits			
A. Direct consumptive benefits			
1	Timber logging	221.30	554,046,680 (Rs. 550 Million)
2	Fuel wood	762.73	1,909,570,828 (Rs. 1,900 Million)
3	Fodder (collection)	546.95	1,369,344,020 (Rs.1,370 Million)
4	Grazing	2607.20	6,527,385,920 (Rs. 6,520 Million)
5	Minor forest produce	195.16	488,602,576 (Rs. 490 Million)
	Total Direct consumptive benefits	4334.61	10,852,129,596 (Rs. 10,580 Million)
B. Direct non- consumptive benefits			
6	Ecotourism Indian visitors – Foreign visitors –	 3061.03 209.04	7,663,594,708 (Rs.7,660Million) 523,352,544 (Rs.523 Million)
	Total Direct benefits (A + B)	7603.42	19,035,922,312 (Rs. 19,035 Million)
II. Indirect Benefits			
7.	Watershed benefits	498329.29	1,247,616,484,400 (Rs. 1247,610 Million)
8.	Microclimatic factors	976.82	2,445,566,552 (Rs. 2,440 Million)
9.	Carbon stock Carbon Flux	111102.12 653.73	278,154,967,200 (Rs. 278,150Million) 1,636,678,428 (Rs. 1,630Million)
10.	Biodiversity	27917.00	69,893,001,200 (Rs. 69,890 Million)
11	Employment generation	168.41	421,631,276 (Rs. 421.6 Million)
	Total indirect benefits (6 to 11)	639150.16	173123,940,000 (Rs. 173,120 Million)
	Total economic value of ecosystem services (I+II)	646753.59	16,192,108,108,000 (Rs.16192.10 Billions)

Framework adapted from Verma, 2000 as used in IIFM- CSO study 2006

Fig. 3.3: Percentage Contribution of ESs from Uttarakhand Forests as Estimated under IIFM-CSO Study



Note: *The study gives close scenario of the neighboring states based on recently developed methodology by Verma, 2000 for CSO. Thus the figures provide closest approximation of TEV estimated by any study for Uttarakhand state. The methodology developed could be used on representative sample basis for estimating the TEV of Uttarakhand.*

Scenario VI: Values of Ecosystem Services of Forests of Uttarakhand Based on Independent Studies conducted by LEAD India and CHEA and other experts under the current project on Valuation of Forest Ecosystem Services in Uttarakhand Himalaya.

Table 3.6: Ecosystem Services Values from Independent and External Studies of Uttarakhand.

S.No.	Ecosystem Service	Study Base and Values	Annual Value in Rupees
1.	Silt control	Nainital Lake Study : 3157 t of silt control from Nainital forest of 242.8 ha, costing Rs. 0.2 Million annually i.e. Rs. 823.7 ha^{-1}	Extrapolating to the Forest and tree cover area of Uttarakhand = 2,062.2 Million for Forest and Tree Cover (FTC) of 25036 Km^2
2.	Carbon Sequestration	Net Accumulation in Biomass@ 6.6 M t C per year @ US $ 10 per t of C (US$ 1 =Rs 45)	US$ 66.1 Million or 2,974.5 Million for the FTC area of Uttarakhand
3.	Soil Carbon pool	263.58 M t C up to 1.5 m depth	US$ 2,635.8 Million or 118,610 Million
4.	Landscape beauty	(i) National Parks (SFD statistics 2004-05) – for the forest area of 24413 km2 (ii) Nainital Lake @ Rs. 3,020 ha^{-1} (Lower estimate) and (iii) Nainital Lake @ Rs. 4,260 ha^{-1} (Upper estimate)	(i) Both from Indian and foreign tourists in the year 2005-06 – 124.4 Million (ii) Extrapolating to FTC of Uttarakhand = 7,560.8 Million (iii) Extrapolating to FTC of Uttarakhand = 10,665.3 million
5.	Logging* Fuel wood* Fodder* and other products	Rs. 1510.6 Million as total revenue earned by forest department (2005-06)	1,510.6 Million as total revenue

(Continued)

Table 3.6: Ecosystem Services Values from Independent and External Studies of Uttarakhand (Continued).

S.No.	Ecosystem Service	Study Base and Values	Annual Value in Rupees
6.	NTFPs	Resin, minor minerals, stone flower or Jhula, Moss grass, MAPs	70.00 Million
7.	Ecological value of forest Succession	(i) Fallow lands (<5years old) @US$ 8.20 ha^{-1} yr^{-1}, (ii) Young Secondary Forest (5-20 Years old)@US$ 20.60 ha^{-1} yr^{-1}, (iii) Old Secondary Forest (>20 Years old)@US$ 6.80 ha^{-1} yr^{-1}	For FTC area using the estimate of Young Secondary Forest = 2,320 Million
8.	Pollination Service (Per ha value is estimated for Forest area in USA 36,504,000 ha).*	(i) Supplementary services of honeybee to native pollinators = US$ 1.6 Billion in USA (for USA Forest = Rs.1972 ha^{-1})* (ii) Estimated value of managed honeybee in absence of native pollinators = US$ 8.3 billion in USA (Rs. 10231 ha^{-1})* (iii) Native benefit of all other pollinators = US$ 4.1 Billion -US$ 6.7 Billion annually	(i) 4,937.0 Million (ii) 25,610 Million (iii) 12,650 Million - 20,670 Million)

* Estimated by Verma, 2007 assuming the value emanating from USA forest area

The above estimates under different scenarios throw light on the important role played by the forests of Uttarakhand and the need for recognition of these values in the accounting system of the state.

Note: This scenario provided collation of assorted studies taken at the primary level thus provide data at the micro level. As recommended in case of V^{th} scenario, this could also be adopted for large sample to represent the state.

Evolving Markets and Incentive based Mechanisms for ESs from Forest

There is increasing appreciation around the world of the role played by forests in providing important environmental services such as carbon sequestration, landscape beauty, biodiversity conservation and watershed protection. As many of these services are facing increasing threats there is recognition that existing, traditional regulatory approaches and public expenditures alone may not suffice to ensure their protection and sustained flow. Thus, in many parts of the world, explicit value is being placed on these services and real payments are being generated for forest owners and managers acting as incentives for conservation. In many cases poor communities residing in upstream catchments in and around forests have an important role to play as stewards of the area. The increased incentives for undertaking conservation therefore hold a huge potential for directly improving their livelihoods. The case of Uttarakhand becomes more specific where the forests constitute an important component not only for the people living in Uttarakhand but also in downstream regions. Thus, stakes of various organizations and communities like the forest department, downstream users, VPs and other conserving communities providing the service, the funding agencies investing in forest capital are very high in conserving the forests of the state.

Paradigm shift from the regulatory centralized and command and control type approach to the need for exploring the relevance of alternative and complementary approaches such as 'Payments for Environmental Services' (PES) is particularly true in the case of Uttarakhand, where over two-thirds of the total geographical area is to be maintained as forests. Such mechanisms are need of the hour on the state of Uttarakhand where the cost of conservation is borne by the forest conserving local communities and the large benefits are reaped by other key

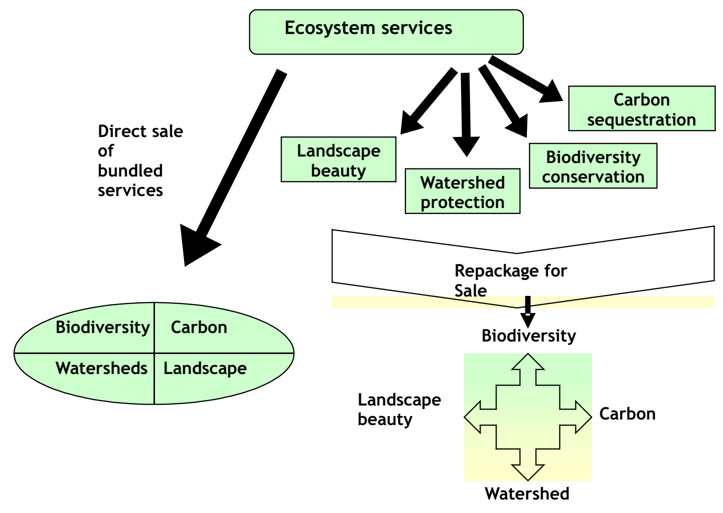
stakeholders. The need for introduction of enough incentives for all forest conserving communities especially the 12,064 VPs of the state conserving 523,289 ha area of the state becomes more pertinent in this case for sustainably managing the strategically located forests of Uttarakhand state. Given this scenario, facilitation of Payment for Ecosystem Services (PES) are extremely relevant in the state, as they offer the potential of addressing both conservation and livelihood concerns.

There has been an increasing trend all over the world to set up mechanisms for PES. A recent global survey found almost 300 new cases of payments across the world. For example, a private Costa Rican utility company voluntarily pays into a fund that provides money for private upstream landholders to increase forest cover. This reduces sedimentation, thus providing sufficient water flow for hydroelectricity generation. In Paraguay, AES, an international power company, paid US$ 2 million to form a protective reserve for one of South America's last remaining areas of undisturbed dense tropical forest. This helps to offset carbon emissions. In Karnataka State, India, farmers have formed a fund with the assistance of an NGO, the Government of India and the Swiss Agency for Development Cooperation to help other local farmers with watershed protection activities such as regenerating forest and maintaining fallow land. Following table (Table 3.7) gives an overview of such PES mechanisms around the world highlighting the main instruments and the actors who need to pay for availing ecosystem services. The past decade has seen the widespread emergence of systems for financial payments for forest ecosystem services.

Economies of Scale for Bundling of Ecosystem Services

The creation of markets for individual ecosystem service often deals with only part of the problem and may in certain circumstances create new distortions. Where markets for service are missing, little investment will be channeled towards production of the service (Natasha, 2002). Instead funds will flow towards sectors where investments yield competitive returns. Creation of market for ecosystem service tends to benefit people from new investment, would increase flow of services and reduce negligence. While focusing on isolated services represent a practical way forward in the near term, to reap the economies of scale the markets for bundled ecosystem service might lead to larger incentives for multiple stakeholders. The following diagram (Natasha, 2002) suggest that either merged bundles i.e. where ecosystem services are sold together and cannot be subdivided for sales to separate purchasers and shopping basket bundles where purchaser can acquire specific services on their own or as a part of a package and land stewards can sell different services to different buyers. The two approaches to bundling may face constraints as the set up costs including the transaction cost of such markets but may ultimately lead to more efficient allocation to resources and higher returns to sellers. Thus this mechanism would require enormous technical data and institutional requirements for successfully marketing a bundle of services to separate buyers.

Fig. 3.4: Bundling of Ecosystem Services



Limitations of Valuing and Paying for Ecosystem Services

Lack of Standardized methodology for valuing and aggregative Ecosystem Services: The system is bested with various problems like lack of organized data in the form of forest stocks and flows, problem of double counting on use and non use values and various intangible like carbon storage, biodiversity, ecotourism, landscape values which exist on account of each other, problem of aggregation of values based on two distinct approaches viz.; namely, 'revealed preference' values and 'stated preference' values etc.

Problem of long and short term benefits: Welfare benefits from preservation of forests have long stream of benefits and such benefits can not be easily written off under current income or welfare schemes thus the need for separate estimation arises.

Problem of double counting: Timber after felling from the forest has a price reflecting its use or utility value. But it has emerged out of the carbon sequestration function of the forest in the past, abating global climate change. Similar problems are faced in other values like biodiversity and recreation.

Benefit Sharing Mechanism: Even once the payment for ecosystem services get generated in the system, the major task remains is that of distribution of such benefits. The formula based NPV committee report on extent of benefits accruing to various stakeholders is considered where the benefits to be distributed as (i) Local- 100% of NTFP, fuel wood and fodder values; 50% of watershed services and 45% of biodiversity values (ii) State- 100% of ecotourism and timber values; 50% of watershed services, 90% of Carbon and 45% of biodiversity values; (iii) National - 10% of carbon and 10% of biodiversity values The increased allocation @ Rs. 70 million per annum has already been effected by the 12^{th} Finance Commission of India and the CAMPA, but the allocation of rewards of conserving communities and suffered communities is yet to be worked out.

Conclusions/Recommendations

1. **Pilot Implementation at Selected Sites**: Sites of clear upstream and downstream linkages of services like in Uttarkashi division which has the maximum area under reserved and protected forest categories (18.9% of the forest area of Uttarakhand state under the department based on legal status), is an abode of Gangotri glacier and watershed of two major rivers of India

2. **Developing Markets for ESs:** They can promote conservation and support local livelihoods since it reward to the resource owners/ managers for their role as stewards in providing ESs. Thus, these markets can increase the economic value of forest ecosystems. As mentioned, 300 such markets exist for ESs across the world. In India such markets have been experimented in the states of Himachal Pradesh and Madhya Pradesh.

3. **Legal and Policy Research:** It would also be necessary to establish practices and benchmarks for fair negotiations between the producers and consumers.

4. **Dissemination of Knowledge about Values of ESs:** As the forests have multistakeholder and multisectoral linkages, the knowledge so generated by the expert group shall be disseminated in the form of working or policy papers on 'developing framework for valuing forests to guide the policy' to them for inculcating appreciation of the concept and need for such a system.

5. **Strengthening the Role of Van Panchayats of Uttarakhand:** The recently released IPCC report on Methodological and Technological Issues in Technology Transfer, 2007 talks intensely about the adaptation mechanisms for climate change. It suggests financial incentives both at the national and international levels to increase the forest cover and area. It also suggests overcoming the constraint of lack of investment capital to help poverty alleviation. As the tenure rights are clear in case of Van Panchayats of Uttarakhand and these have been engaged since long in sustainable forest management and avoiding deforestation, VPs can be a good contender in carbon credit mechanisms.

6. **Preparation of a manual to facilitate operationalization:** A manual containing basic concepts, procedure for economic valuation and accounting of forests may be prepared for handy use by the end users.

7. **ESsValuation and Accounting Framework as a Component of Working Plan:** The valuation exercise should be made a component of the forest working plans. As the working plans are prepared every 8-10 years at the forest division level, the accounting framework can also be affected.

Table 3.7: Examples of Payment for Ecosystem Services (PES) across the world*

Name of case study	Water-related ecological service provided	Supplier	Buyer	Instruments	Intended Impacts on forest	Payment
Self organized private deals						
France: Perrier Vittel's Payments for water	Quality drinking water	Upstream dairy farmers and forest landholders	A bottler of natural mineral water	Payments by bottler to upstream landowners for improved agricultural practices and for reforestation of sensitive infiltration zones	Reforestation but little impact because program focuses on agriculture	Vittel pays each farm about US$ 230 per hectare per year for seven years. The company spent an averaged of US$ 155,000 per farm or a total of US$ 3.8 million
Reforestation but little impact because program focuses on agriculture	Regularity of water flow for hydroelectricity generation	Private upstream owners of forest land	Private hydroelectric utilities, Government of Costa Rica and local NGO	Payments made by utility company via a local NGO to landowners; payments supplemented by government funds	Increased forest cover on private land; expansion of forests through protection and regeneration	Landwoners who protect their forests receive US$ 45 $ha^{-1}yr^{-1}$, those who sustainably manage their forests receive US$ 70 ha^{-1} yr^{-1}, and those who reforest their land receive US$ 116 ha^{-1} yr^{-1}
Cauca River, Colombia: associations of irrigators' payments	Improvements of base flows and reduction of sedimentation in irrigation canals	Upstream forest landowners	Associations of irrigators; government agencies	Voluntary payments by associations and government agencies to private upstream landowners; purchase by agency of lands	Reforestation, erosion control, spring and waterways protection, and development of watershed communities	
Trading Schemes						
Australia: irrigators financing upstream reforestation	Reduction of water salinity	New South Wales State Forests (state government agency)	An association of irrigation farmers	Water transpiration credits earned by State Forests for reforestation and sold to irrigators	Large-scale reforestation, including planting of desalination plants, trees and other deep-rooted perennial vegetation	Irrigators pay US$ 40 ha^{-1} yr^{-1}, for ten years to NSW state forests. Revenues are used by State Forests to reforest on private and public lands. Private landowners receive an allowance but rights remain with State forests.
Public payment schemes						
New York City. Watershed management program	Purification of New York City's water supply	Upstream landowners	Water users taxed by New York City with supplemental funds provided by federal, State and local government	Taxes on water user, New York City bonds; trust funds; subsidies; logging permits; differential land use taxation, development rights; conservation easements; development of markets	Adoption of low impact logging; retirement of environmentally senstive land from agricultural production; forest regeneration	Dairy farmers and forester who adopted best management practices were compensated with US$ 40 million, which covered all their additional costs. Foresters who improved their management practices (such as low impact logging) received additional logging permits for new areas, and forest landowners owning 50 acres or more and agreeing to commit to a ten-year forest management plan are entitled to an 80% reduction in local property tax.
Columbia; environmental services tax (eco0tax) for watershed management	Regularity of water flow for industrial uses; regularity and water	Private landowners and municipalities	Industrial water users and municipalities	Eco-tax on industrial water users; payments by municipalities and watershed authorities to landowners	Improved forest management, expansion of forests	NA
US: conservation reserve program	Reduction of soil erosion, improvement of water quality and regularity of stream flow	Owners of cropland and marginal pasture lands	US Department of Agriculture	Conservation easements; restoration cost-share agreement; yearly rental payments to landowners for engaging in conservation, additional incentive payments	Though the program is directed at farms, advantages to trees are many, planting, strips, riparian buffers, grassed waterways, field windbreaks, shelter belts, living snow fences, and establishment of bottomland timber	Farmers receive US$ 125 ha^{-1} yr^{-1} and are compensated for 50% of costs to establish approved conservation practices. Total government cost US$ 1.8 billion yr^{-1}

* International Tropical Timber Organisation (ITTO), The Current Status of Future Potential of markets for ecosystem services Provided by Tropical Forests, Technical series No. 21, October, 2004.

Chapter 4

Other Forests Ecosystem Services of Uttarakhand

4.1. Goods and Services from Oak and Pine Forests

In the most populated belt of the mountainous part of the Uttarakhand (1000-2000 ,m altitude) oaks (*Quercus spp.*) and pine (*Pinus roxburghii*) trees form most of the forest cover (Singh and Singh, 1992). In this region, oak and pine forests cover about 12.3% and 16.4% respectively, of the total forest area legally under the management of SFD. Local people depend on these forests for a variety of goods and services for their subsistence living (Table 4.1.1). The oak forest is valued by local people of the region as these are the source of quality goods such as, fuel wood, year-round green fodder, nutrient-rich leaf litter (oak = 1.72% and pine = 1.02% nitrogen; Negi and Singh, 1993) used as organic manure, nutrient-rich soil, and a variety of NTFPs including medicinal plants. Further most importantly people believe that oak forests retain water for longer period, resulting in a sustained water yield (Kumar and Verma, 1991). Among the important goods provided by the pine forests are timber and resin. Bark of pine wood is the most preferred fuel by the blacksmiths. Pine forests produce good amount of herbaceous fodder because of their open canopy, frequent forest fires and litter removal by villagers for animal bedding(Semwal, 1990; Semwal and Mehta, 1996).

Oak and Chir Pine forests dominate large tracts of forests in mountainous parts of Uttarakhand

There are examples where people have maintained community Pine forests, which provide them a number of goods and services (Negi and Bhatt, 1993). Soil and water conservation (SWC) is considered among the most important services generated by the Oak forests, however not yet proved experimentally (Negi, 2002). Oak forests are also known for rich biodiversity (Dhar *et. al.*, 1997). Pine wood does not make a good fuel and its litter(needles) deposition on forest floor restricts growth of many species (Singh and Singh, 1992). Pine being a fire-resistant and stress-tolerant species proliferates in inhospitable habitats where oak cannot grow. Generally soils are deep and fertile in an oak forest. The slow growing oak requires suitable microsite conditions (e.g., deep, moist and fertile soil) for growth and survival. Pine is capable of colonizing to landslide sites (Singh and Singh, 1992). Common observations reveal that on most of the hill slopes where pine has colonized, the slopes are relatively stable as compared to adjacent barren hill slopes. On the contrary oak requires mature and disturbance free habitats to grow

and regenerate. Therefore, in terms of landscape stability pine has comparative advantage over oak at least initially. The economic benefits from pine forests, such as resin and minor timber are also important and have higher market value than most of the locally valued goods collected from oak forests . The revenue earned annually from the sale of various forest products (Table 4.1.2) was about 27 times more for the pine forests (Rs. 10.7 million) than the oak forests (Rs.0.63 million).Thus, there are certain advantages associated with each of the two forest types.

Table 4.1.1: Some Ecosystem Services Provided by Oak and Pine Forests in Uttarakhand (Source: Negi and Agrawal, 2003).

Ecosystem goods and services	Oak forests	Pine forests
Ecosystem goods		
Fodder	Year-round	Non-palatable
Fuel wood	Good quality	Inferior quality
Seed	Edible	Edible
Medicinal value	Some	Some
Minor forest products/edibles	Many	Few
Small Timber	Rarely used	Frequently used
Agricultural implements	Frequently used	Rarely used
Resin	No	Yes
Bark of tree	No specific use	Used by blacksmiths
Manuring leaves	Good quality	Inferior quality
Other use of leaves	None	Roofing / Brooms
Biomass production	10-20 t/ha/yr	Comparable
Ground herbage yield	Low	High
Ecosystem Services		
Carbon sequestration	High	Low
Nutrient cycling	?*	?
Under storey vegetation	Well developed	Poorly developed
Plant diversity	High	Low
Faunal diversity	High?	Low?
Fire resistance	Low	High
Survival / regeneration potential	Low	High
Soil conservation	High?	Low?
Water quantity regulation	High	Low
Water quality	High?	Low?
Microhabitat for flora and fauna	High?	Low?
Aesthetic value	High?	Low?

*?Denotes enough scintific information is not available on the concerned aspect.

Table 4.1.2: Mean Values of Different Products Obtained and Revenue Earned (Rupees) from Oak and Pine Forests in district Almora, Uttarakhand (Source: Forest Office, Almora)

Forest Type	Area (ha)	Firewood (m^3) (1993-2000)	Timber(m^3) (1993-2002)	Resin (t) (1995-2002)	Bark (kg) (1999-2002)	Torch Wood (kg) (1999-2002)	Lichen (kg) (1999-2002)
Oak Forest	8793.3	23.6	-	-	-	-	37,900
Revenue earned	-	0.01	-	-	-	-	631,000
Pine forest	42732.6	-	4468.1	1004.6	2000	170,000	-
Revenue earned (Rs.)	-	-	451,000	15,800,000	14,000	693,000	-

As evident from the foregoing, superior goods (e.g., fuel wood and fodder) provided by the oak forests compared to pine forests had put the former under severe stress for the want of these resources by the local communities. As a consequence oak forests have been squeezed to a few mountain peaks physically inaccessible to the people, and pine being an early successional species has colonized vast areas, which were originally under oak forests (Singh *et. al.,* 1984). Anthropogenic disturbances are also reflected in the decline of tree stocking density in the forests of this region. For example, between 1973 and 1989 forests having good crown cover (>60%) declined annually at a rate of 27.8 ha yr^{-1} in a watershed of Gaula river, Kumaun Himalaya (Rathore *et. al.,* 1997). A case study in Almora district of this region has reported highly fragmented occurrence of pine forests (patches having an area less than 5 km^2) in densely populated areas (Sharma *et. al.,* 2002), thereby indicating the increasing dependence of the natives on the pine forests. Therefore, the role of pine forests in maintaining agroecosystems in the montane zone of this region seems to have assumed more important role especially in terms of ecosystem functions as compared to the otherwise highly valued but scarce oak forests.

Significance of Oak and Pine Forest Resources in Traditional Agriculture

The functioning of hill agroecosystem depends upon the flow of biomass and energy between forests, cropland, man, livestock and private support land. Two case studies by Ralhan *et. al.*(1991) and Negi and Bhatt (1993) one agroecosystem entirely dependent upon the resource of oak forests and another on pine forests make it amply clear that the magnitude of forest goods extracted by the local communities are different from one another (Table 4.1. 3).

In the oak forest dependent agroecosystem (village- Nanpapo 1450 m amsl Pithoragarh district) the annual fuel wood consumption is estimated to 177 **t**, which converts to Rs. 87,615 per year. Of this about 90% is collected from the surrounding forests. Similarly, the total fodder extraction is computed to 1045 **t** yr^{-1} (i.e., worth Rs. 40,964 per year), of which the contribution of private support land is only about 14%. Manuring leaves collected from the forests totals about 19 **t** yr^{-1} and converts to Rs. 10,450 per year. Therefore, the total value of forest goods derived for agroecosystem functioning amounted to Rs. 140,000 per year for the studied village. However, the forest biomass collected from the forests for agricultural implements, small timber and other NTFPs could not be estimated .

In the Pine forest dependent agroecosystem (village - Naugaon; 1140 m amsl in Almora district) of the total of about 120 **t** fuel wood consumed every year (equivalent to Rs. 16,500) contribution of pine forests (community forest+Govt. forest) is computed to around 25%, the remainder was met through the private support land. Similarly, the fodder extracted from the nearby forests was 175 **t** yr^{-1}, which costs Rs. 22,138. The contribution of pine forests (community forest+Govt. forest) to the total fodder consumed was about 23% **,** the rest was met from crop residues and other sources. The annual extraction of wood for agricultural implements and leaf litter for manuring leaves was amounted to Rs. 6,050. Thus, a comparative account of per capita biomass consumed in two villages dependent upon the two different forest types indicate that consumption of both fuel wood and fodder was markedly high in the village dependent upon oak forest indicating local importance of oak forests.

Table 4.1.3: Biomass and Energy Flow from Two Different Forest Ecosystems to Agroecosystems in Mountain Villages of Uttarakhand (after Ralhan *et. al.,* 1991 and Negi and Bhatt, 1993).

Goods extracted from the forests	Biomass (useable weight, t $village^{-1}$ yr^{-1}.)		Money value (000' Rs. $Village^{-1}$ yr^{-1}.)	
	Oak Forest	Pine Forest	Oak Forest	Pine Forest
Fuel wood				
-Government forest	160	9	79.2	1.2
-Private support land	17	111	8.4	15.3
Total	177	120	87.6	16.5
Fodder				
-Government forest	904	22	35.4	2.8
-Private support land	141	153	5.5	19.4
Total	1045	175	40.9	22.2
Wood for agric. implements	-	2	-	0.3
Manuring leaves	19	11	10.5	6.1
Minor Forest products	?	?	?	?
Money value of the resources collected from the forests (Rs.)	-	-	139.0	45.1

Conclusion/Recommendations

It can be inferred that ESs vary from one forest type to another and determined also by human dependence on different types of services offered by a given forest type. There are many ecological and social aspects where oak forests score over pine forests but at the same time in some particularly economic term pine forest too have an edge over the former. The goods and services provided by the livestock component (such as milk, dung,meat, skin, wool, traction energy, etc) are an integral part of hill agroecosystems that are maintained through the goods and services supplied by the nearby forest ecosystems. Detailed investigations are required to further identify and determine quality and quantity of a whole range of goods and ESs particularly those highlighted in Table 4.1.1 generated by these two major forest ecosystems of Uttarakhand. The superiority of one forest ecosystem over the other with regards to goods and services provided would be helpful in refining the regeneration / afforestation approaches in the state. Such studies would offer better choices for decision making in planning landuse and determining the optimum proportion of forest land under each forest type. Further, it is not easy to document all the ESs precisely, and to make people perceive their roles in forest conservation. It is the perceptions of the users regarding these forests that would affect the valuation of ESs generated by oak and pine forests in the state.

4.2. Grazing- A Forest Ecosystem Service

The economy of Uttarakhand is predominantly agro-pastoral and livestock based. As the land holdings are marginal and scattered , the crop yield alone cannot meet the daily needs of the local peasants. Thus, livestock component that provides milk, meat, wool, hides, skin, traction power, for agricultural operation (occasionally transport) and dung (for manuring the crop fields) supplement the subsistence living. In addition, livestock provide gainful employment to a substantial section of population. The woolen products traditionally made by the Bhotiya tribes and that has a specific demand in the market is one such example. Traditionally, the pastures in sub- alpine and alpine regions, community grazinglands that exist in most of the villages, fodder trees grown / protected by the people on their terrace raisers and wastelands, and crop residues have been the source of fodder for the livestock of the local communities. The livestock composition in this region is represented by cattle (47.5%), buffaloes (12.3%), goats (15.9%) and sheep (10.4%) (Chander and Harbola, 1996). Regional trends indicate that the populations of cattle, buffalo and sheep have marginally decreased in the recent decades whereas population of goat has increased, due to increased market demand of goats for meat.

Fodder Resources of Uttarakhand

Alpine meadows called Buggyals are extensively used for livestock grazing during summers in Uttarakhand

There are about 350 fodder species from 116 genera growing throughout the region between 500 and 4500 m amsl (Singh and Singh,2006). The Himalayan region support about 84 trees and 40 shrubs of fodder value that the people use (Negi, 1977). Singh and Singh (2006) have estimated that in Uttarakhand the fodder production from forests, agricultural sector, orchards and bushes/ perennial herbs accounts for 77%, 12%, 2.7% and 19.2%, respectively. Singh *et. al*. (1988) computed contribution of different sources of fodder for the Uttarakhand Himalayan (Table 4.2.1). A few case studies compiled from different parts of Uttarakhand reveal that the contribution of crop residue ranges from 13-41% and that of grazing from the surrounding forests and grazinglands from 35-45% (Table 4.2.2). According to Nautiyal *et. al.* (1998) 20% of annual fodder requirement is met from farm trees and 30% from crop by-products in a typical village located in sub-montane zone of Garhwal where traditional agroforestry is well developed. In many villages a sizable chunks of land (also referred to as *Ghasnis*) have been developed as grasslands to cater to the fodder need of the livestock that also serve as a source of income to the households that maintain Ghasnis (Box 4.2.1). In general, grazing in forests, unculturable wastelands and seasonal cropland fallows are the mainstay for animals in Uttarakhand. Also, fodder trees, shrubs and crop residue contribute significantly to the livestock dietary demands. A cost estimate of the fodder and leaves collected for cattle bedding from the surrounding forests and private support land revealed that each year a total of 5,748 kg (equivalent to Rs. 6,380) fodder is extracted from the reserved forests, 2,037 kg (equivalent to Rs. 2,260) from the private support system consisting of private grasslots and fodder trees, 3, 471 kg bedding leaves (equivalent to Rs. 1,920) from reserve forests for cattle sheds per ha of cropland has been recorded (Singh *et. al.,* 2002). Further analysis showed that on average 30 animal units have been found dependent on each hectare of cultivated land that in the state

Abandoned agricultural fields are also used for livestock grazing

consume fodder costing Rs. 14,700 annually to produce an output of Rs. 3130 (milk, Rs. 585; animal labour utilized Rs. 1,340; and dung Rs. 1205with the output: input ratio of 0.2 (Singh *et. al.,* 2002).

Table 4.2.1: Total Fodder Yield (Dry Matter) from Different Sources in Uttarakhand (based on J.S. Singh *et. al.*, 1988).

Source of fodder	Fodder yield		Percent of the total
	Dry matter ($\times 10^4$ t yr^{-1})	Energy value ($\times 10^{12}$ kcal yr^{-1})	
Tree leaf [a]	320.3?	12.8	43.5
Herbaceous ground flora	146.4	5.5	18.7
Leaves of trees around crop fields[b]	23.9	0.9	3.1
Grassland of the forested zone	15.0	0.6	2.0
Degraded land of the forested zone	107.5	4.3	14.6
Alpine meadows	70.0	2.8	9.6
Crop residue	62.5	2.5	8.5
Total	745.6	29.4	100.0

[a]Taken as 50% of the total leaf production from total forest area; as the conifer forests which account for approximately 50% of the forest area, and do not yield tree leaf fodder; [b]The leaf production of trees maintained by villagers around their crop fields is equal to 0.48 t dry matter per year for each ha of cultivated area. This multiplied by the actual cultivated area of 4.6×10^5 ha gives 23.9×10^4 t dry matter yr^{-1}. Using energy equivalent given in Mitchell (1979) dry matter was converted into energy.

Table 4.2.2: Contribution of Different Sources of Fodder to the Livestock Consumption at some selected locations in Uttarakhand.

Location	Source of fodder (%) to total consumption					Total fodder consumption	Reference
	Crop residue	Stall-fed (ground fodder)	Grazing	Tree fodder	Reserve Forest		
Dugar Gad Watershed, Pauri- Garhwal	13	37	45	5	-	703 t	Negi *et.al.* (2002)
Three villages of Pithoragarh District	37	-	-	18	45	29-51 t ha^{-1} yr^{-1}	Ralhan *et. al.* (1991)
Four Kumaun Himalayan villages	22	-	-	28	50	422×10^5 kcal ha^{-1} yr^{-1}.	Negi & Singh (1990)
Naugaon village Almora)	41	16	35	8	-	507.5×10^5 kcal ha^{-1} yr^{-1}.	Negi, *et. al.* (1989)

Box 4.2.1: Payment for Fodder from Ghasnis

In most of the villages in Uttarakhand, the village common land is utilized by the inhabitants for grazing, and protection of ground fodder. People employ a range of practices to utilize the village commons for various ecosystem goods (i.e., fodder, fuel wood, leaf litter for cattle bedding, wild edibles, wood for agricultural implements etc.) considering the type of land, production potential and land tenure system. Protection of ground herbage seasonally (locally known as Ghasnis) is a practice frequently used by the people for the management of village community lands. In this practice a sizeable chunk of land is excluded from cattle grazing and harvest of grass is not allowed year-round through social-fencing (watch and ward). During post-rainy season through winters when the fodder from agricultural crops and other sources is diminished, these grass lots are opened for harvest of fodder and subsequently for grazing until the next summer. Each partnering household's share is demarcated generally with a rectangular piece of land, locally called as "Mange", for harvesting the grasses . A few households who do not require fodder either due to surplus from other sources or due to low or no livestock, sell the grass lots to neighbors. The rates are fixed as per the prevailing rates in the locality/area. Sometime auction of such grass lots is also practiced. The fodder is thus works like an incentive for the Ghasnis owner and further promotes conservation and regeneration of grasslands - a system close to PES at local level. This system is quite rewarding to the households those are still dependent upon livestock for their subsistence living.

Climatic, topographic and physiographic factors influence the occurrence, productivity and quality of the forage material that grows in various grasslands. The net aboveground biomass in mid-elevation grasslands has been found 2.2 -2.9 t ha^{-1} (Melkania and Singh, 1989). Semwal and Mehta (1996) reported the grassland productivity of pine forests as 3.1 t ha^{-1} yr^{-1}. In the high altitude pastures the biomass productivity has been reported 1.62- 3.96 t ha^{-1} (fresh weight) in Uttarakhand (Ram and Singh, 1994). Negi *et. al.* (1993) reported these values ranging from 1-3.2 t ha^{-1} for Bedani-Ali alpine meadow (Box 4.2.2). Table 4.2.3 provides an overview of biomass production of some of the grasslands/grazing lands investigated by several workers in this region. The values ranged from 0.6 3.96 t ha^{-1} yr^{-1}. Grass production for the entire Uttarakhand state has been estimated at 80 x 10^5 t (Table 4.2.4) (Singh and Singh, 2006). Depending upon the level of sustainable harvest, the carrying capacity of entire fodder producing system of the region is exceeded by 1.5-2.3 times (Singh *et. al*., 1988). Since the entire fodder producing area is not available/ accessible to the livestock, the carrying capacity would be exceeded in greater degrees near to the areas of human settlements. Such areas are not producing the ESs as they used to provide before and deteriorating gradually in the want of appropriate conservation mechanisms.

Table 4.2.3: Plant Biomass/Net Production in Various Grazinglands of Uttarakhand.

Location	Plant biomass production (t ha^{-1})	Reference
Baideni- Ali (Chamoli)	2.54	Ram & Singh (1994)
Panwali Kantha (Chamoli)	2.17	-do-
Rudranath (Chamoli)	3.96	-do-
Tungnath (Chamoli)	1.62	-do-
Baideni-Ali (Chamoli)	1.0-3.2	Negi *et. al.* (1993)
Low-altitude Himalaya	2.8-15.7	Melkania & Singh (1989)
Mid-altitude Himalaya	2.2-2.9	-do-
High-altitude Himalaya	2.3-3.7	-do-
Temperate grasslands	0.6-2.0	Tincheng & Yuangang (1989)
Alpine meadows	2.4-5.3	-do-

Table 4.2.4: Grass Production from Different Land use Types in Uttarakhand (Source: Singh and Singh 2006).

Land category	Area ($\times 10^5$ ha)	Grass production ($\times 10^5$ t)	Percent contribution
Non culturable & fallow land	5.23	14.23	17.8
Permanent pasture, grazing land, alpine meadows	2.29	2.93	3.6
Agriculture land	2.71	2.60	3.3
Forest land	26.24	54.57	68.3
Orchards, other areas	3.04	5.60	7.0
Total	39.51	79.93	100.0

Box 4.2.2: Pasture use by Migratory Livestock in an Alpine Meadow *(Buggyal) of Uttarakhand*

In Uttarakhand approximately 1.4 million ha is covered by high altitude pastures (*Buggyals*). These Buggyals are utilized for summer grazing (May- October) and provide nutritive forage to the migratory livestock (horses, sheep, goats and cattle) of transhumance communities as well as livestock from lower valleys. Since in the lower altitude valleys livestock grazing far exceed the carrying capacity of grazing lands (Singh *et. al.,* 1988), transhumance to alpine meadows has become an essential mode of supporting livestock. A detailed study was conducted by Negi *et. al.* (1993) in Bedani Ali, Chamoli district, revealed that as many as five plant communities were foraged by sheep, goats, horses and cattle for different plants and plant parts. The biomass productivity of the plant communities was found ranging from 1.83- 3.19 t/ha. Of the total 60 plant species that grew in the meadow, excluding rare species, the three animal species (horses, goats and sheep) together grazed upon 30 and 10 species were commonly grazed by all of them. In most of the plants, leaves and flowers were eaten with succulent stems. The dry matter (DM) intake per animal per day averaged across the grazing season for horses, sheep and goats were 3.25 kg, 0.74 kg and 0.40 kg, respectively. During the grazing season a total of 552 t DM fodder was removed by the grazing population. The horses consumed 58.3 t, sheep 409.8 t, and goat consumed 83.4 t. Thus, of the total of 1672 t DM forage produced in this meadow only 33% was consumed and the meadow was regarded within the carrying capacity (Singh, 1991).

Conclusion/Recommendations

Traditionally livestock supplement house hold income in various ways in Uttarakhand. To maintain good quality livestock local communities need scientific information on the nutritional values of various fodder resources, their availability in nature, designing suitable grazing regimes, methods for raising quality fodder near villages to meet shortfalls and quality improvement of the existing fodder resources. While doing so the changing livestock composition in the wake of changing socio-economic scenario should also be taken into account.

4.3. Role of Forests in Soil Formation

Forests contribute in soil formation through physical, biological and chemical weathering of parental rock materials and also through the addition of litter and its subsequent decomposition to which some economic value could be attached. The forests of Uttarakhand Himalaya contribute immensely in soil formation, nutrient transfer from them to another ecosystem types particularly to agroecosystems with in the region as well as downstream through numerous river connections. At regional scale they help regulate the flow of water and nutrients to the

Gangetic Plain supporting agriculture based livelihoods of more than 500 million people. Age old practices of shifting agriculture in the eastern Himalaya and slash and burn agriculture *Katil* in Uttarakhand depend on soil fertility developed by forests over several years. Himalayan Alder (*Alnus nepalensis*) forest is particularly useful for supplying nitrogen to plantations or croplands located downstream (Singh,2002).

Limited studies carried out in some major forest types in the Himalaya suggest that litter removal from forest floor causes highest degree of soil degradation in sal (*Shorea robusta*) followed by mixed hardwood and chir pine forests Schmidt *et. al.* (1993). Singh *et. al.* (1998) reported that forest soils were more acidic (pH; 6-6.3), lighter (bulk density 0.62-0.87 g cm^{-3}) and had higher organic carbon (3.4-4.2%) compared to agricultural soils (pH, 7-7.8; bulk density, 1-1.1 g cm^{-3}; organic carbon 0.3-1.2%). An analysis in Pranmati watershed in Uttarakhand Himalaya spread over an altitude of 1000-3800m (Ghosh *et. al.,* 1997) revealed that none of the pine forest sites had organic carbon>3%, 27% samples collected from oak forests, 33% from mixed forest and 11% of agricultural soils had organic carbon in the range of 3 to 7.5% (Table 4.3.1). Thus, the influence of forest types on soil fertility was discernable as pine forest soils wer poorer in organic carbon compared to broadleaved forest and agricultural soils.

Table 4.3.1: Spatial Variation in Soil Organic Carbon (0-15 cm) in Pranmati Watershed Uttarakhand Himalaya (Adapted from Rao *et. al.*, 2005)

Soil property	Organic carbon range (%) in different land use/land cover types (n=98 auger cores distributed systematically and collected in the month of June)					
	Pine forest	Oak forest	Mixed forest	Farmland	Scrub	Alpine pasture
Organic carbon (%)						
Very low (<1.5)	55	27	32	32	50	0
Low (1.5-3.0)	45	46	34	57	50	0
Medium (3.0 - 7.5)	0	27	33	11	0	0
High (>7.5)	0	0	1	0	0	100

Litter fall, Decomposition and Nutrient Release Pattern in Major Forest Types

Forest ecosystems have a role in soil formation and in maintaining soil fertility through litter accumulation (organic matter) and its subsequent decomposition. The major role of organic matter is in the development of soil structure and hence soil fertility. Slower the rates of decomposition, slower will be the nutrient supply to the primary producers resulting in accumulation of large nutrient stocks in the soil. Soil fauna play crucial role in litter decomposition. Mycorrhiza though, typically account for less than 1% of ecosystem biomass can account for almost 15% of the ecosystem productivity. Mycorrhiza infestation is lower in soils swept clean of forest litter when compared to the non swept soils. The decomposition agents other than fungi are protozoa, nematodes, bacteria mites and earthworms and a variety of litter feeding arthropods representing micro, meso and macro fauna.

In the Uttarakhand Himalaya evergreen tree species form most of the forest in elevation ranging from 300m to 2200m (Singh and Singh, 1992). They are characterized by spring/summer leafing with simultaneous leaf drop. Species showing this character include both conifers (e.g., *Pinus roxburghii*) and broadleaf species (e.g., *Quercus* spp.) (Ralhan *et. al.*, 1985; Negi and Singh, 1992). Deciduous species which generally occur in the forests of lower elevation also begin bearing leaves during the spring and early summer seasons after remaining leafless during the winters (Nov-March). Trees and other vegetation (shrubs and herbs) return a major part of the nutrients through litter fall to the soil drawn from it every year. A study on some major tree species of forests in Uttarakhand (Negi and Singh, 1993) reported that senesced leaves contain 0.98 (*Rhododendron arboreum*), 3.15% (*Alnus nepalensis*) nitrogen just prior to leaf drop. The average ratio of leaf dry matter to N concentration of the senesced leaves is computed to 67%. All these plant parts fall on the forest floor and make up the upper most layer of organic debris (dead vegetal matter). In addition to the litter lying on the forest floor, there are dead roots of trees and other herbaceous annual plants on the forest floor together are referred to as the organic matter that contribute in maintaining soil fertility and soil formation.

Litter fall

Litter fall apart from being an important source of nutrient return to the soil also helps in the formation and renewal of forest floor. The standing litter mass on the forest floor is an important structural component of a forest ecosystem. It protects the soil, influences hydrology and establishment and growth of seedlings, and hence the plant community development (Singh and Singh, 1992).

Litter fall from the woody vegetation (tree and shrubs) in the forests of Uttarakhand ranges between 4.2 and 7.7 **t** $ha^{-1}yr^{-1}$. In the Sal (*Shorea robusta*) dominated forests in the foothills, the annual litter fall is 6.6 t $ha^{-1}yr^{-1}$ in chir pine forests (6.5 **t** $ha^{-1}yr^{-1}$) and in the oak forests (5.8 - 7.7 **t** $ha^{-1}yr^{-1}$). Tree leaves account for 60-80% of the total litter fall and the woody litter contributing to 14-31% (Chaturvedi, 1983; Pandey and Singh 1981 b; Singh and Singh, 1992). These values are higher by 40-84% reported for temperate forests (Roden and Bizilevich, 1967) of the world. The herbaceous vegetation also contributes significantly to the total litter biomass that ranges from 0.6 to 1.2 **t** $ha^{-1}yr^{-1}$ and is 8.5 to 17.5% of the total litter fall (Table 4.3.2).

Table 4.3.2: Litter fall (t ha^{-1} yr^{-1}) in Different Forests of Uttarakhand Himalaya

Forest type	Woody vegetation litter (t ha^{-1} yr^{-1})				Herbaceous litter (t ha^{-1} yr^{-1}) (B)	Total litter (t ha^{-1} yr^{-1}) (A+B)
	Leaf	Wood	Miscellaneous	Total (A)		
Sal	4.0	1.4	1.2	6.6	1.0	7.6
Chir pine mixed broadleaf	3.2	0.6	0.4	4.2	0.8	5.0
Chir pine	4.6	1.8	0.1	6.5	0.6	7.1
Rianj oak	5.0	1.4	1.2	7.7	1.2	8.9
Tilonj oak	4.2	1.2	0.6	6.0	1.0	7.0
Mixed banj oak-chir pine	4.2	1.2	1.0	6.3	1.0	7.2
Banj oak	4.6	0.8	0.2	5.8	1.2	7.0
Mixed oak-conifer	4.2	1.2	0.2	5.5	NA	
Kharsu oak	3.2	1.2	0.1	4.6	1.0	5.6
Cypress (*Cupressus torulusa*)	3.2	1.6	0.2	5.0	NA	

(A= sum of leaf, wood and miscellaneous litter fall from woody vegetation; B= litter generated from herbaceous vegetation; and C= A+ B (based on Chaturvedi, 1983; Mehra *et. al.,* 1985; Pandey and Singh, 1981b; Rawat, Y.S. and Singh 1989); NA=Not available

Litter Decomposition

The rates of decomposition of leaf litter of the major species of the two elevations (sal and chir pine mixed broad leaf forest) of the Uttarakhand Himalaya are 0.253 - 0.274% day^{-1}. The rates of decomposition of all the oaks of the region except *Quercus lanuginosa* (Rianj Oak) are fairly similar (0.182-0.196 % day^{-1}). The decomposition rate of chir pine is slowest among the species of the Uttarakhand Himalaya. Pine litter takes 789 days and oak 669 days for complete decomposition in forest floor (Upadhyay and Singh, 1997). The rates of decomposition in oak forests are relatively faster due to high humidity and higher population of soil fauna in oak dominated forests (Singh *et. al.*, 1990). When the litter of both the species was placed in agricultural fields, pine litter took 1042 days and oak 926 days for complete decomposition (Negi, 2002). High Carbon and low Nitrogen content (one of indicators of litter quality) of pine litter as compared to oak is responsible for its slower decomposition (Table 4.3.3). Generally leaves of deciduous species decompose faster than the evergreen species like oak and pine.

Table 4.3.3: Weight Loss in Common Leaf Litter (*Quercus leucotrichophora*) Placed in Different Forest Sites of Uttarakhand (adapted from: Singh and Singh, 1992).

Forest site	Elevation (m)	% Weight loss in one year
Sal	300	99
Chir pine mixed broadleaf	1350	88
Chir pine	1750	75
Mixed banj oak-chir pine	1850	77
Mixed oak	2150	88

Nutrient Input to Forests

Although litter fall is the major route through which nutrient return from the biomass to the soil pool, a substantial amount (11-46%) reaches the soil pool through rainfall via canopy through fall and stem flow. The nutrients returned through this process are in 'available' form and thus play a role in the faster nutrient cycling in ecosystems (Pathak and Singh, 1994). The total annual input of nutrients by precipitation (through fall + stem flow) and litter fall across the major forest types of the region, namely sal forests, pine mixed broadleaf forests, pine forests, mixed oak- pine forests, mixed oak-rianj dominated forests and mixed oak-tilonj dominated forests varies between 169.3 kg ha^{-1} and 268.7 kg ha^{-1}. Nitrogen input was computed from 55.6- 82.4 kg ha^{-1} yr^{-1}, Phosphorus (5.8 - 8.5 kg ha^{-1} yr^{-1}), Potassium (K) (31.9 - 60.4 kg ha^{-1} yr^{-1}) and Calcium (68.6 - 120.2 kg ha^{-1} yr^{-1}) across different forest types (Table 4.3.4). The present data provide an idea of the contribution of forests in maintaining the soil fertility.

Table 4.3.4: Annual Input of Nutrients by Precipitation Components (through fall + stem flow) and Litter Fall in Different Forest types of Uttarakhand (based on Mehra *et. al.*, 1985)

Nutrients	Input by precipitation components (kg ha^{-1})	Input by litter fall (kg ha^{-1})	Total input (rainfall + litter fall) (kg ha^{-1})
Sal Forest			
N	9.1	69.8	78.9
P	1.7	5.4	7.3
K	15.2	31.4	46.6
Ca	18.2	80.7	98.9
Mg	11.99	N.A.	N.A.
Total Nutrient Input (railfall+litter fall) = 231.7 kg ha^{-1}			
Pine-mixed broadleaf forest			
N	7.9	47.7	55.6
P	1.7	4.1	5.8
K	16.5	22.9	39.3
Ca	17.8	50.8	68.6
Mg	15.8	N.A.	-
Total Nutrient Input (railfall+litter fall) = 169.3 kg ha^{-1}			
Pine forest			
N	11.4	56.9	68.3
P	2.1	6.4	8.5
K	23.3	37.1	60.4
Ca	25.7	74.2	99.9
Mg	16.5	N.A.	N.A.
Total Nutrient Input (railfall+litter fall) = 237.1 kg ha^{-1}			
Mixed oak-pine forest			
N	8.5	69.4	77.9
P	1.4	4.4	5.8
K	16.1	28.5	44.6
Ca	18.2	86.3	104.5
Mg	12.9	N.A.	N.A.
Total Nutrient Input (railfall+litter fall) = 232.8 kg ha^{-1}			
Mixed oak-rianj dominated forest			
N	10.2	72.2	82.4
P	1.7	5.4	7.1
K	27.9	32.3	60.2
Ca	29.8	89.2	119.0
Mg	14.5	N.A.	N.A.
Total Nutrient Input (railfall+litter fall) = 268.7 kg ha^{-1}			

Transfer of Nutrients from One Ecosystem to Another

The green foliage and litter of forest are major sources of animal fodder and Farm Yard Manure (FYM) for replenishing agriculture soil fertility in Uttarakhand. There is generally one-way flow of nutrients from the forest to the agriculture fields. The implications of this kind of forest management where the forest floor is swept almost clear of the leaf litter have not been well documented.

Some preliminary estimates suggest that the average quantity of input to the crop fields in this region is 3.9 t ha^{-1} yr^{-1} though it may go up to more than 25 t ha^{-1} yr^{-1} for certain crops such as potato having high market demand. Undoubtedly, the productivity of crops increases due to the nutrient subsidy received from the forests but the impact on the forests are less clear. Studies have reported reduction in soil carbon and Nitrogen in the forest from where litter removal is high (Thadani, 1999). The organic carbon in crop field soils is generally one-fourth to one-eight of the adjacent forest soils. A study of the maize crop field for one season of 108 days in Uttarakhand indicated that the soil organic carbon is reduced by 1,650 kg C ha^{-1}, which about 28% of the initial Carbon mass in the soil.

The impact of agriculture must be measured, at least, in terms of the loss of revenue due to overexploitation of forests and a decline in their productivity. The inefficiency of the system would be found to be even higher, if the cost of the net loss of nutrients and soil from croplands was also considered. For example, irrigated paddy cropland during the rainy season suffer a net loss of Nitrogen (Sharma, 1989), which has been calculated as the cost of the chemical fertilizers required to compensate Nitrogen loss at Rs. 3000/ha. The inefficiency of the cropland system is further magnified as nitrogen input of 60 kg ha^{-1} yr^{-1}, to crop fields (through manure) falls within the range of Nitrogen input through litter fall to the soil of an oak forest of the region. While Nitrogen level of forest soil remains stable, the crop field soil loses Nitrogen at the rate of 75 kg ha^{-1} yr^{-1} (Sharma, 1989) that exceeds the yearly input through manure.

Conclusion/Recommendations

Soil formation is one of the major ESs generated by the forests of Uttarakhand Himalaya, yet available scientific information on the role of forests in soil formation, soil fertility maintenance, and nutrient transfer from one ecosystem to another considering local and regional scales is extremely scanty. Almost no information is available on how the rate of soil formation varies across different terrestrial ecosystems of a region under the influence of same climate, how the rate of soil formation is affected by subsequent deforestation and how magnitude and frequency of litter removal from forests floor in Uttarakhand for FYM preparation affects forest soil fertility and formation (Singh, 2002). Variations in site characteristics and time of sampling in a seasonal climate may account for huge variation in soil chemical properties. A systematic grid based soil sampling design could provide better insights on soil fertility-land use/land cover relationships (Rao *et. al.,* 2005).

4.4. Forest Succession and Restoration of Degraded Forest Sites

Forest succession can be defined as a directional change in time of the species composition and vegetation physiognomy of a site where climate remains effectively constant (Finegan, 1984). Succession begins at various points of time and moves through a series of pioneer trees species to a group of mature forest tree species. Succession is interpreted as a process of development of the ecosystem towards maximal stability (resilience to disturbance) and maximum efficiency of resource use (Odum, 1971). Successional change is thought to be orderly and predictable and therefore deterministic converging into a particular kind of forest from various different starting points. Various kinds of changes occur in a forest ecosystem during the process of succession. They change the characteristics of the land where the forest is growing and have considerable impact on ESs. By its very nature, succession in forest ecosystems increases the cycling of resources, and attributes like Carbon sequestered by the system increase with time.

The geodynamically active and fragile mountainous terrain of Uttarakhand is prone to soil erosion, landslides and other natural hazards that lead to mass movements of soil and nutrients, leaving the site bare and infertile. The continued pressure on vegetation for fuel, fodder and other resources further adds to the fragility of hill slopes. In Kumaun lesser Himalaya (Uttarakhand), Joshi and Goel (1988) found that anthropogenic (12%) and techtenogenic (50%) landslides together account for 62% of total landslides**.** The amount, type and annual distribution of rainfall also influence the other factors that control landslides, such as vegetation, soil and steepness of slopes (Valdiya**,** 1987, Bhandari and Gupta, 1985). Murthy *et. al.* (2004) observed an interesting behavior of landslides in Alaknanda valley of Uttarakhand Himalaya. He found that the area normalized incidence has gradually increased from closed forest to degraded forest like in the case of pine forest. The landslide incidence is 0.1428 for closed pine forest, which increased to 0.2181 and 0.3111 for open and degraded-pine forests. In this case it can be concluded that density of pine forest appears to be slope-stabilizing factor. In the case of oak forest also a similar trend has been observed. Closed oak has 0.0085 landslides per km^2. followed by open oak (0.0098) and degraded oak (0.1882). Pine has shallow root system as compared to oak, which is a broadleaf species with deep root system. Characteristics like root system pattern, plant height and canopy size, and the incidence of landslides are related and reflected in the occurrence of land slides.

Land slides/land slips are frequent in Uttarakhand Himalaya, surrounding forest cover helps faster restoration of such sites

Large landslides devoid of the past vegetation create a bare slope for primary succession, while the smaller one creates a mosaic of sites with and without original vegetation. Often a landslide site experiences recurring soil erosion and mass movements and the size increases gradually. Studies on plants colonizing the recurring landslides sites (1-90 year old) around 1900 m altitude at Nainital (Singh and Singh, 1992; Pandey and Singh, 1985) found that annual species (such as *Achyrnathus bidentata, Justicia simplex, Polygonum amplexicaule*) having ability to produce large amount of seeds and their efficient dispersal colonize the young landslides. With the increase in age of landslides, a number of herbaceous perennials (e.g., *Heteropogon contortus*, *Boenninghusenia albiflora, Muhlenbergia duthiena* etc.*)* occupy these sites, thus prohibiting immigrants through niche pre-emption. The chrono-sequences of herbs represent a situation similar to "relay-floristic" or the "facilitation model" of Connell and Slatyer (1977). They found that the seed source of the herbaceous flora mainly come from the adjacent forested site. Recovery of landslides also seem to be facilitated by the colonization of some pioneer tree species those have superior growth features (such as, rapid shoot growth, large leaf area per shoot and leaf number per shoot) as compared to other tree species (Negi, 2006).

cm; mean leaf area 49 cm^2), *Aesculus indica* (shoot length= 19.6 cm; mean leaf area 76.6 cm^2) and *P. ciliata* (shoot length= 18 cm; mean leaf area 78.5 cm^2), *S. alba* (shoot length= 27.7 cm and leaf number per shoot 20.7) are among some examples to cite (Negi, 2006). These species were further characterized by greater retranslocation of nitrogen from senescing leaves to the trees; a strategy that allows nutrient conservation in the nutrient poor landslide sites (Vitousek and Reiners, 1975).

Apart form the above species winter deciduous trees, mainly *Alnus nepalensis, Aesculus indica, Acer pictum, Carpinus viminea, Fraxinus micrantha, Juglans regia, Pyrus lanata* are found generally along moist places and streams between 2000 and 2800 m altitude in Uttarakhand Himalaya. Along the freely draining slopes *Alnus nepalensis and Hippophae salicifolia* often form pure stands on the freshly formed landslips. Both of these pioneer deciduous species are nitrogen fixer and improve soil fertility, which eventually facilitates their replacement by late successional species. Thus, vegetation and a layer of decomposing litter cover bare ground area. Hydrological studies have found low soil loss (range = 0.012 and 0.057 t ha^{-1} for rainy season) for in the forests of this region as compared to other land uses (Negi *et. al.,* 1998).

Estimates from Costanza *et. al.* (1997) indicate that the ESs provided from forests are considerably more than other types of cover. For example, the value of climate regulation (estimated at $ 223 $ha^{-1}yr^{-1}$) is over twenty times greater than the services provided by pastures or farms. Erosion control ($ 245 $ha^{-1}yr^{-1}$) is over four times more valuable from a forest when compared to a farm or pasture (Portela and Rademacher, 2001). Thus secondary succession from a farm or pasture to a mature forest is a process of increasing value of ESs. These variations in value when applied over large forest areas add up to staggering sums of money. As deforested land returns back to forest cover through successional processes, the sediment load eroded from the forest decreases thereby increasing the value of ESs. Succession, in particular during the initial stages, leads to a rise in biodiversity.

It can be inferred from the foregoing that succession is a process by which degraded and disturbed ecosystems return to forested landscapes. This is a process driven by nature and requires no human inputs or expenditure. Through this process, lands associated with low ecosystem value (as is the case with landslide sites and degraded lands) naturally progress into areas associated with higher levels of ecosystem values into forested landscapes that can better intercept rainfall, reduce runoffs, filter air pollutants, and support habitats with greater micro site diversity that leads to higher biodiversity. Succession is thus a natural process that increases biological and economic values of the landscape and is hence an important ecosystem service. In Uttarakhand it has been observed that the vegetation recovery on bare sites created by landslide is far quicker than sites located in degraded forest landscapes elsewhere.

Conclusion/Recommendations

Little is known how rates of colonization of degraded forest sites by early successional plant species are affected by the proximity of these sites to good forests. Detailed scientific studies are required to evaluate the total value of forest succession considering the quantity of soil and soil nutrients loss minimized and hydrological regulations brought about. Studies are also required to show how the process of succession could be accelerated for faster recovery of degraded forests in Uttarakhand. The value of recovery of landslide sites through natural regeneration could be estimated by assuming the cost of new plantations established and the value of timber from such plantations per ha basis. The bio-engineering approach of landslide stabilization (Agrawal *et. al.,* 1997) also needs to be compared with the natural course of landslide recovery through plant succession.

4.5. Role of Forest Types in Regulating Spring Discharge

In the mountainous areas of Uttarakhand springs emanating from a variety of land use recharge zones are the main sources of fresh water for household consumption. Although spring water yield is largely a function of geological attributes (such as geomorphology, soil structure, rock type, structural aspects of rocks - faults, fractures and lineaments), the land use (grazing land, agriculture, forest fire) and land cover (forest types that influence the rainwater interception and evapotranspiration) are also known to influence the spring water yield, water quality and longevity of spring discharges and seasonal discharge patterns (Valdiya and Bartarya, 1991; Negi and Joshi, 1996 and 2004). Therefore, each spring shows different discharge patterns (Negi and Joshi, 1996). Geology, rock type and anthropogenic activities in the recharge area are also known to profoundly influence water quality of the aquifers (Kumar *et. al.,* 1997; Joshi and Kothyari, 2003) (Table 4.5.1). In recent decades, gradual drying up of the springs in Uttarakhand, low discharge during dry months, and perennial spring becoming seasonal have been reported across Uttarakhand (Singh and Rawat, 1985; Singh and Pande, 1989). It has been observed that these activities (e.g. land use and land cover change, biotic interference) in the fragile watersheds have caused soil erosion, depletion in soil organic matter and concomitant loss of water absorption capacity of soil, resulting in a too-much-and-too-little water syndrome in the region (Valdiya and Bartarya, 1989).

Table 4.5.1: Water Quality of Springs under Different Land use/ Cover in Uttarakhand (source: Negi *et. al.,* 2001) (S= Seasonal spring; P= Perennial spring).

Spring	Major land use in the spring recharge area	Water quality parameters					
		Ca^{++} (mgL^{-})	Mg^{++} (mgL^{-1})	F^{-} (μgL^{-1})	Cl^{-} (mgL^{-1})	No_3^{-} (μgL^{-1})	Total hardness (mgL^{-1})
Ali (S)	Pine forest	8.4	3.8	52	4.0	21	38
Palsain (S)*	Agriculture /pine forest/ settlements.	11.8	2.4	63	6.0	30	40
Masi Kaflani (S)	Pine forest/Forest bland	13.9	5.5	81	6.0	115	59
Panath (S)	Oak/ Pine forest	10.9	2.8	82	12.0	89	30
Nirkot (S)	Agriculture/ Abandoned land	11.3	3.1	85	11.0	37	42
Sainchar (P)	Agriculture	25.2	10.5	332	25.0	3000	110
Bhimli Talli (P)	Grazed wasteland	8.4	7.1	156	4.0	120	50
Bhimli malli (P)	Agriculture/ Grazed wasteland	12.6	26.5	186	4.0	260	140
Raila Tewari(P)	Agriculture/ Settlements	7.6	11.7	83	3.0	12	110
Bhattgaon (P)	Pine forest/ Agriculture.	8.4	2.9	83	7.0	3	34

*S= Seasonal spring ij = Perennial spring

A study conducted at 1210-1550 m amsl (mean annual rainfall 968-2551 mm; mean annual evaporation 701 mm) in two watersheds (one dominated with pine forest 9% area, and another with oak forest, 50% area) in Pauri district of Uttarakhand, revealed that although geology of the spring recharge area was found to be the main controlling factor of the amount and pattern of spring discharge, the spring recharge area characteristics seem to also have influence on the spring discharge. For example, Barsuri spring with lowest recharge area (3.5 ha) yield annually (2.63×10^6 L) water, which is comparable to Bhimli Talli (2.68×10^6 L) that has the largest recharge area (Table 4.5.2). In other words, Ali spring yield was low (12L/1000L of rainfall) as compared to Basuri spring (85.1 L/1000 L of rainfall). The Ali spring that has pine forest in the recharge zone recorded the minimum discharge (i.e., 1.21% of the total annual rainfall) as compared to Barsuri spring (8.51% of the total annual rainfall) that has oak forest in the spring recharge zone. This signifies the importance of oak forest as compared to pine forest in Uttarakhand. The broadleaf oak forests allow the infiltration of rainwater into the soil stratum more efficiently due to the interception by under story vegetation, litter layer and soil organic matter. In the pine forests the understory vegetation is almost absent and the ground vegetation is limited due to recurrent forest fires. Therefore, the rainwater does not have much chance to percolate and it runs off downstream rapidly.

Efforts are being made to enhance water retention potential of forests by digging artificial ponds and other vegetative means

Table 4.5.2: Spring Discharge under Different Land Use /Cover Recharge Zones

Spring	Apparent recharge area (ha)	Slope/ Aspect	Relative level of biotic interference	Mean annual discharge ($X10^6$ L)	Water yield of spring (% of the annual rainfall)
Ali	20.9	36^0 /SW	Moderate	3.70	1.21
Bhimli Malli	12.1	12^0 /SE	Moderate	4.51	3.93
Bhimli Talli	40.7	10^0 /SE	High	2.67	6.40
Sainchar	7.6	20^0 /SE	High	2.62	2.63
Srikot	19.9	30^0 /SE	High	1.51	1.23
Barsuri	3.5	65^0 /SE	Low	2.63	8.51

(Adopted from : Negi and Joshi, 2004)

It is also evident from the above study that large recharge zone area may not be favourable with regard to water yield as the evapo-transpiration demand would be very high. The smaller recharge zone will be easy to protect and manipulate for desired land use / cover. Oak forest are regarded for their higher soil and water conservation function in this region . Pine forests are blamed for exploitation of soil moisture due to fast growth and shallow root system, which feed on surface water received through rainfall. Land use and land cover such as moderately grazed pasture, abandoned agricultural terraces and few trees but dense growth of bushes and oak forest in the spring recharge area were found conducive for higher spring discharge and may be promoted for long-term water resource conservation and water availability.

Conclusion/Recommendations

There is a growing evidence to suggest that the protective value of tree stands lay not so much in the ability of the tree canopy to break the power of raindrops, but rather in developing a litter layer (Dalal *et. al.,* 1961). Oak forests are characterized by thick litter layer that allows more infiltration of water into the soil stratum (thereby delaying storm runoff) but also reduces soil erosion. High altitude forests function as a store house of water for many of the perennial rivers arising from this region. Land management practices should aim to increase the evergreen broadleaf species at the expense of conifers. We emphasize the need for the establishment of evergreen protection forests (a practice used in mountainous areas elsewhere; Plamondon *et. al.,* 1991) in Uttarakhand where soil and water conservation are the two most crucial issues of ecosystem stability. However, the effects of forest conversion on water yield and quality must be better quantified to support the establishment and proper management of protection forests for enhancing the flow of ecosystem services.

Chapter 5

Forest Governance Practices in Uttarakhand: Experiences from Van Panchayats

Historical Background

Like other parts of the county, the control of colonial government over the forests started in Uttarakhand in the latter part of the 19th century. In 1864, the Governor General of India mooted the idea of abolishing the proprietary rights of individuals on the forests as such rights were perceived to be detrimental for forests. To exercise the control over the forests of the country, the need for having separate legislation was felt and thus the first Indian Forest Act of 1865 came into existence. Traill (1815-1835), the second commissioner of Kumaon division, conducted as many as seven land settlements during his tenure and defined village boundaries during the course of his forth settlements in 1823 (*Vikrami Samvat* 1880, better known as *Sala Assi ki paimaish* in Uttarakhand). Initiatives were taken by commissioners to control indiscriminate fellings and shifting cultivation.

The new Forest Act 1878 divided the forests into two categories, protected and reserved forests. Further the Government Notification of 17th October, 1893 included all the *benap* (unmeasured land that belonged to government) land under protected forest category. Deputy Commissioner was given powers of Conservator of Forests over these lands. In 1902, the protected forests were further divided into two parts, closed civil forests and open civil forests. The closed civil forests were considered necessary by the government for preservation of forests and wildlife. In the open civil forests the village community was allowed to exercise their traditional rights of *Gauchar* (a common grazing land for village cattle), *Panghat* (water source) and forests. However, with the immediate effect of the passing of Notification of 1893, the people's right of extension of agricultural holding over *benap* land was terminated. Area under the reserved forests category enhanced further in 1904 and again in 1917. Due to excessive damage caused to oak forests, during 1878-1917, these forests were also placed under the management of forest department. Activities like felling of trees, grazing and extension of cultivation in these forests were also prohibited as part of the management plan.

Forest settlements and various restrictions imposed on the customary rights of the local communities led to massive resentment against such restrictions imposed by the Colonial Government. From 1911 to 1917 vast areas of forests were burnt down by the local people in protest against the restrictions. The agitation of local communities to protect their traditional rights over the forests was formed into national level political movement.

To resolve the conflict the government appointed a committee 'Kumaon Forest Grievances Committee' in 1921, to inquire into the rights of people over forests. On the recommendation of this committee one of the major decisions taken by the Government was to form Panchayati Forests known as Van Panchayats(VPs) in the hill region of the then United Province and now known as Uttar Pradesh from which the state of Uttarakhand had been carved out in the year 2000. These were formed from the class-I reserved forest areas within the village boundaries. These forests since 1931 have been managed by the village level committees known as VPs. Formation of VPs was viewed as a friendly gesture of government to accept and honor the bonafide rights of the people of Uttarakhand over forest resources for whom the forests are still the source of earning livelihood.

For management, the forests in Uttarakhand have been divided into protected forests, reserved forests and

protected areas. The protected forests are also known as civil and soyam forests. The reserved forests are managed and controlled by the State Forest Department (SFD) protected forests and VPs are under the administrative control of the State Revenue Department (SRD). The SFD is expected to provide technical support and guidance for the management of these forests also.

The VP forests covering over half a million ha area are being managed by more than 12,000 VPs (Table 5.1). The local village communities are substantially depend on their VP forests for fodder,fuel wood, and leaf litter requirements. The relatively satisfactory condition of the majority of VPs is an indication of the success of forest governance at local level. However, in the changing socio-economic and environmental scenario there is a need to further strengthen the VPs by addressing financial resources , gender issues, and other constrains being faced for efficient management.

Table 5.1: Distribution of VPs in Uttarakhand and Geographical Area (Source: VP Atlas 2006, Uttarakhand).

S.No.	District	Van Panchayats	Area (ha)
1.	Nainital	495	28,068
2.	Almora	2199	69,853
3.	Pithoragrah	1666	87,054
4.	Bageshwar	822	38,783
5.	Champawat	629	31,233
Sub total Kumaun division		**5811**	**2,54,990**
6.	Dehradun	215	7,685
7.	Tehri	1332	1,3180
8.	Rudraprayag	574	2,0701
9.	Uttarkashi	644	7,265
10	Chamoli	1082	1,88,355
11	Pauri	2431	52,814
Sub total Garhwal division		**6278**	**2,89,974**
	Grand Total	**12,089**	**5,44,965**

Legal Framework

VP is the oldest participatory forest management institution in the country notified under the Van Panchayat Rules of Indian Forest Act (IFA) 1927. Legally these forests have the status of village forest under section 28 of IFA. First Van Panchayat Rules were notified in 1931 under District Schedule Act. Subsequently after the repeal of District Schedule Act, these rules were notified with some changes in 1972 and 1976, when Uttarakhand continued as a part of Uttar Pradesh. After formation of Uttarakhand, there have been two amendments in the VP rules. The Uttarakhnad Panchayati Forest Rules (UPFR) revised in 2001 followed by another revision in 2005 were to accommodate various suggestions of the communities pending for last 25 years (since 1976) in general, and also to fulfill obligations of the 73rd constitutional amendment entrusting Panchayatiraj Institutions with environment protection. For the first time in 2001 in the history of Vps, provision of reservation for women and weaker sections of the society in the VP committee was enforced .

The VPs represent one of the oldest experiments of participatory forest resource management in collaboration with the state in the world. It has a legal backing, and has an elected body, called VP Management Committee (forest council), which is assigned the task of managing village forest resources. The administrative control (formation of VP, election and other administrative works) is with the SRD, and the SFD provides the technical support under the VP rules. The ownership of these forests is with the government, and the areas are assigned to the communities for management. The usufructs and revenue used by the communities as per VP rules.

A VP management committee is comprised of nine members elected by the village VP members. The condition to have only one member from a family has been imposed. Then the nine members elect a head 'Sarpanch' of VP from among themselves. A villager could not be elected as Sarpanch for more than two consecutive terms. The Sarpanch has the following responsibilities: (a) to convene and preside over all meetings of VP (b) keep watch over the finances and bring any irregularity in finance in notice of VP (c) look after the legal matters (d) supervise and control the staff and establishments maintained by VP. Elections are held after every 5 years. Four seats are reserved for women. One seat out of remaining five seats is reserved for the male members of the Scheduled Caste and the Scheduled Tribe. If a member of the Scheduled Caste or the Scheduled Tribe does not reside in the villages concerned then the aforesaid seat is treated as unreserved. The Sub Divisional Magistrate, upon fulfilling the procedures and having no objection within 30 days from the election, declares the formation of management council. The detail of VP formation process, rights and responsibilities and other provisions are described in the Uttarakhand Panchayati Forest Rules (UPFR) 2005.

Present Scenario

Functioning:

The VPs in Uttarakhand, governed by the UPFR, 2005 have obligation to follow two major provisions i.e. to formulate the Micro Plan (Section 12 of the UPFR) and the Annual Implementation Plan (Section 13 of the UPFR) for preparing and execution of management activities for the community forests. These are expected to be prepared and implemented by each VP in the state.

It has been observed that in practice the condition of preparing micro plans or annual action plan is not being strictly followed. A few VPs prepare these plans but often not able to implement them due to financial constraints. The increasing number of VPs in the state *vis -a -vis* the limited staff in SFD and SRD, technical assistance and facilitation for preparing plans is the another major constrain.

Capacity building exercise of Van Panchayat members

VPs in the state have their own routine procedures and actions for managing their community forests. Normally the decisions are taken in the management committee meetings and are mostly focused on protection of forests and fodder, fuel wood, leaf litter regulations.

For protection purposes, in general, a watchman is appointed to guard the forest, and his salary is paid from VP funds. He reports to Sarpanch against offenders. In some villages, households watch the forest on a rotational basis. A VP may grant permission for cutting grass, grazing and collection of fallen wood, and may charge fees for these provisions with the permission of the state government. The other rights include extraction of pine resin for domestic and medicinal purpose and disposing of trees with the permission of SRD albeit on the advice of SFD. The trespassers can be fined up to Rs. 500. However, upto certain extent each VP makes it own local rules and regulations such as imposition of fines, as per local needs and wisdom.

Desire to prevent outsiders from using village forest and to become self sufficient in firewood, leaf litter (for manuring crop fields) and fodder is said to be the driving force for the development of community forests in some villages with a high level of success.

Biomass Extraction and Conservation

Van Panchayat resources are used by villagers for subsistence involving collection of firewood, fodder and forest litter, grazing / browsing by livestock. Occasional permission is granted to bonafide users for timber extraction for household or community use , provided the proposal is passed in the VP meeting. Rotational grazing and collection of biomass are followed to allow forest regeneration .

Gender Issues

Though at least four women representatives are required to be in the VP management committee, their forced inclusion has not led to genuine participation . The women representatives either send their son or husband, they are reluctant to attend the VP meetings. The most obvious constrain is the heavy workload involving bulk of child care, collection of fuel wood, fodder, litter , water, cooking and other household and agricultural activities. Also they feel that they are not encouraged by men to attend the meetings. In the surveyed VPs in Almora district it was observed that either women seats in VP committees were lying vacant or the representation is less than desired under VP rules. In recent years this issue has been highlighted repeatedly and men in some cases welcome women participation, but not much progress has yet been made.

Success and Failure

Typically, the VPs are non functional where village forest area is inadequate to meet the community needs (according some estimate at least 1 ha of good forest is required per household); where out migration is high; where government officials are insensitive; and where VP committee members are busy with other occupation like maintaining shop and jobs in near by areas. However, in many areas VPs have been successful in conserving forests clearly indicates their importance.

Till 2002, approximately half of the villages (VP Atlas, Uttarakhand 2006 reports 6000 VPs formed in 2002) in Uttarakhand of the total 15,761 inhabited villages, were having VPs. This was the time when state government initiated a drive to form VPs in each village in hill districts of the state. The number of VPs has increased to more than 12,000 till 2006. Most of the VPs formed in this phase are formed to achieve the target and the area demarcated is often very small and hence they often lack the spirit of a truly community based institution. However, it could also be treated as a transition phase where in first step communities are equipped with the natural resources in the form of their own VP. Another phase to strengthen the existing VPs, both newly created and age old ones is the need of time.

Governance Issues

The VP rules formed by the state government have witnessed a paradigm shift with regard to decentralization of management of forests in the state. The recent amendments in the VP rules (2001 and 2005) have provisions for reservation for weaker sections of society and women. Benefit sharing has been oriented to make it community friendly. A comparison of VP rules of 1976, 2001 and 2005 indicates that attempts have been made to follow the spirit of 73rd amendment of Indian constitution. Ensuring representation of women and weaker sections in the VP committee, increased stake of Panchayatiraj Institutions in benefit sharing from the revenue, provisions for formation/ extension of VPs even in the reserve forest areas, enhancing technical support from the forest department in terms of preparation of micro-plans are some of the positive changes that have been brought about recently. A provision for formation of advisory committee for VPs at block, district and state levels has been introduced in UPFR, 2005. However, the rules do not explain about the functioning, rights and responsibilities of these committees.

Election Process

Observations and secondary information accumulated over the last several years was validated by conducting a field study across 50 VPs in Uttarakhand to understand the governance issues. It was found that more than 95% of the sitting council members were re-elected. Election of Sarpanchs is also based on the wisdom of village elders (Fig.1). The election process indicates that the enthusiasm among the villagers for coming to VP's management committee is weak as compared to Gram Sabaha elections.

Fig. 5.1: Formation process of the Executive committee

Financial resources

It was found that 41% of the surveyed VPs have not received financial support from any source to impliment various VP activities . The government funding, including the benefit shared by the government with the VPs for extractions of NTFPs (resin from pine forests in most of the cases) has been the major source of revenue for 32% VPs. In some cases VPs (19% VPs under the survey) also received funding from various government schemes. About 6% VPs received support from NGOs / private sources and only 2% VPs got financial support of Gram Panchayat .

This is worth mentioning that the VPs having chir pine forest have significant income from resin extraction carried out by the state forest corporation on behalf of VPs. As mentioned in VP Atlas, Uttarakhand, 2006, that a total of Rs. 65 millions in Kumaun division and Rs. 8.3 millions in Garhwal division is available with VPs in Uttarakhand. However, this is interesting to note that this amount is concentrated amongst a few VPs rich in chir pine forests. If the total number of VPs in the state i.e. 12,089 are considered the average available fund per VP is only about Rs. 60,000 which is an insignificant amount for the proper management of VP forests in present day context.

Though based on general observations and inferences drawn from other studies, it is believed that the forests managed by VPs are generally in better ecological conditions than those managed under other regimes, comprehensive studies are still lacking to support these observations conclusively. According to Baland, *et. al., (*2006) the fuel wood demand on the forests could be moderated if the forests are managed by the VPs, though the impact would not be uniform throughout the state . The study further concluded that if all state protected forests are converted to VP forests, firewood use would be predicted to fall by 20%, comparable to what could be achieved with a Rs. 100 subsidy per LPG cylinder.

According to recent amendments in VP guidelines in Uttarakhand, new VPs can be constituted even by bringing Reserve Forest areas under its management. The VPs are also functioning as Joint Forest Management (JFM) Committees under the newly established Forest Development Agency (FDA) initiated during 10th five year plan which is a registered body under society registration act at Forest Division level. The FDAs provide financial and technical assistance to JFM committees including VPs. It is too early to evaluate the impacts of this new partnership between VPs and FDAs on forest protection and local livelihoods .

The Clean Development Mechanism (CDM) of Kyoto Protocol provides incentives to developing countries including India through Carbon trading by creating carbon sink. However, CDM made it practically impossible for communities to opt for Carbon sequestration projects as there is no incentive for the existing forests and efforts local communities put to avoid deforestation in over half a million ha of forest area managed by VPs in Uttarakhand. International negotiators tend to forget that even the deforestation avoided continues to provide valuable ESs.

Benefit Sharing and Concept of Self Help Group

The UPFR, 2005, for the first time, have introduced a concept of Self Help Group/ Forest Users Group within the frame of a VP. The VP can enter in contract with the SHG/ FUG or even with an individual member of Panchayat for "plant, maintain, and earn" scheme. The benefit sharing from income from use of VP land/ resources would be as follows:

- 15% of the income from forest produces to Gram Panchyat.
- 15% of income from forest produce would be earmarked for development of VP and will be kept in VP fund.
- 70% of income from forest produce would be for the SHG member (s), as mentioned in the contract.

In addition the net income from other NTFPs such as resin etc, the benefit sharing would be as follows:

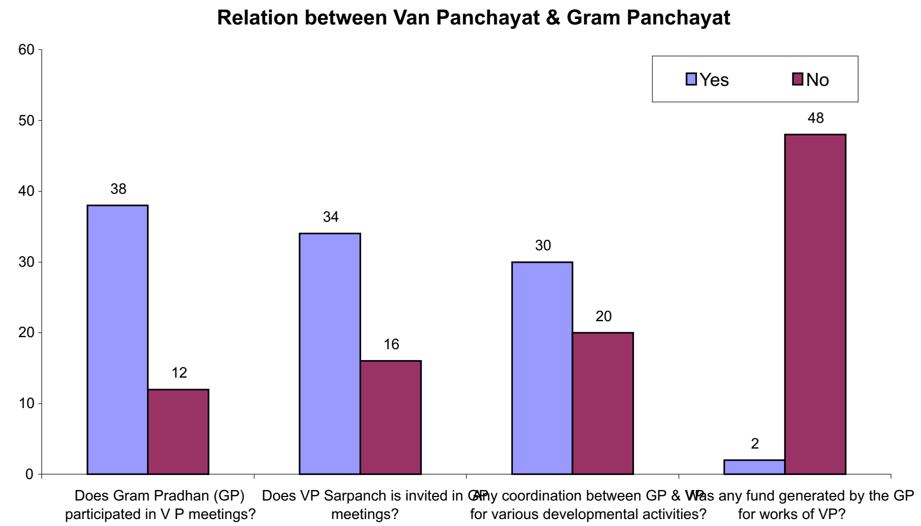
- GP would be allocated 30% funds for undertaking community development works.
- VP management committee would receive 40% funds for VP development and follow-up activities.
- Management committee of concerned VP would use remaining 30% funds for schemes of local relevance and its follow-up.

Thus, the latest UPFR have more liberal benefit sharing mechanism where the concerned Gram Panchayat is also allowed to utilise available resources for community development works.

Relationship between Gram Sabha and Van Panchayat

Although the UPFR, 2005 have provisions for benefit sharing between Garam Panchayat and VP, there are limited examples of successful interaction and collaboration between these two village level institutions. Gram Panchayat rarely makes attempts for mobilising financial resources for VP activities.

Fig 5.2:



It is evident from Fig. 5.2 that Pradhan, Gram Panchayat and VP Sarpanch participate in general house meetings of each other's institutions in their official or individual capacity. The cooperation between the two institutions was defined as positive by 60% respondents during a survey conducted in VPs. However, in practical terms there were only two GPs who contributed in mobilising financial resources for the VP of their respective villages.

This indicates that VPs often work in isolation and funds reaching to villages under various developmental schemes are confined to GPs only. To have efficient local environmental governance effective collaboration between GP and VP is recommended.

Major Constraints

The VPs are one of the oldest and unique village level institutions, in Uttarakhand are facing some constraints, as listed below :

- Non-availability of adequate financial resources .
- Non viable size of majority of new VPs.
- Lack of staff in SFD for micro planning of a large number of VPs. It is expected that the forest management e

- experience with the SFD would facilitate villagers to develop micro plans for VPs for a period of 5 years followed by annual action plans. The growing number of VPs and limited personnel with SFD is a mismatch.
- Ban on commercial exploitation of trees above 1000 m amsl has limited the scope of forestry management by VPs. The Forest Conservation Act 1980 and the Environment Protection Act, 1986 of Government of India have enforced many such provisions those are supporting conservation, however, the traditional rights of the people over their community forests have also declined due to these.
- Weak marketing / forward linkages for NTFPs including MAPs, which has resulted in failure in linking rural livelihoods with their natural resources.
- No compensation for ESs provided by VP forests, despite Uttarakhand received Rs. 350 million for 5 years of a total of Rs. 10,000 million allocated by the 12th Finance Commission of Government of India for better management of forests in the country.
- Lack of coordination between different development departments, which results in isolated and sectoral approach of forest management. Simultaneous implimentation of other developmental activities in the villages, forest management activities get less attention from the villagers .
- Provision to satisfy construction timber demand is lacking. Illegal timber harvesting from VP forests by locals for household use is a management issue being faced by many VPs in the state.
- The decreasing relevance of regulations is more evident from encroachment on VP forests for sustaining agricultural activities. Large areas under VP forests as well limited resources in the Uttarakhand make the management situation more complex.
- The UPFR, 2005 have some provisions that are opposed by the local communities and activists. The basic demand of the communities and activists is to develop more democratic and non-bureaucratic mechanism for addressing occasional problems of the VPs not functioning properly. The UPFR, 2005 have given much administrative control to Sub Divisional Magistrate and to the District Magistrate, the later as appealing authority. Often it has been observed that due to work pressure these officials keep VP related issues on their lowest priority. With the increased number of Vps, a practical and suitable option is required. The major objections raised by the activists and community members that hinder normal functioning of VPs are :
- Bar on the eligibility for election as Sarpanch for more than two consecutive terms.
- Restrictions on the right to sanction tree for bonafide use of right holders.
- Allowing SHG or individuals to get community land on lease under "plant, maintain and earn" scheme may result in depriving communities from their traditional rights over their forests. A few activists visualize this as curtailment of community's rights over their natural resources.

Thus, UPFR, 2005 are still having some lacunas to ensure efficient, democratic and transparent governance mechanism of VPs.

Conclusions/Recommendations

In a forest resource rich state like Uttarakhand, local environmental governance has immense value and scope for sustainable management of natural resources. Van Panchayat is an institutional mechanism that has been in existence since early 1930s to foster efficient forest governance in the state. Symbiotic relations between forests and local communities have been effectively demonstrated through this age-old institution. Recognised under Indian Forest Act, 1927, the VPs have a scope to strengthen local forest governance in ways that ensure economic earning from forests to local communities and also effective conservation of forest resources in the state. Research in some selected VPs of the state under Kyoto theme "Think Global, Act Local" indicates that these community forests sequester 3-4 t Carbon ha^{-1} yr^{-1}. The contribution of VPs in mitigating global warming effects needs to be appreciated by allocation of resources for efficient forest management in Uttarakhand.

Although the state government has taken significant steps to upscale the number of VPs and thus the forest area under their management , there are some problems in effective functioning of these VPs. The spirit, as committed in UPFR, 2005, has to be incorporated in routine functioning of the VPs across the state. Timely elections, ensuring desired representation of women and weaker sections, feasible micro plans and annual action plan and realistic distribution of responsibilities among government officials are the major areas that need immediate attention. There is also a need to define the role and responsibilities of newly introduced concept of advisory committees at block, district and state levels. To take advantage of collective strengths of these committees, they are required to perform a coordination role, conflict resolution efforts among the VPs and also financial resource mobilisation related tasks.

The government run scheme at forest division level under the aegis of Forests Development Agency (FDA) is an attempt to address the need of forest protection and local livelihood. Till 2005, 35 such FDAs became functional with 1,346 JFM Committees with an outlay of Rs. 520 millions in Uttarakhand. However, such state intervention in VPs, needs in-depth evaluation. It is required to examine the issue of benefit sharing between the local communities involved and forest department to consider the community's stakes and to take measures accordingly.

The state has expressed willingness to share equitable conservation benefits with the VPs through state funds. Keeping this in view some of the possibilities could be to subsidize LPG for cooking purposes or availability of seedlings/ saplings of horticulture, bamboo and fodder species to the VPs. However, to identify the innovative schemes and equitable resource sharing mechanism further participatory studies are required.

Livelihoods of rural communities in a forests resource rich state are significantly high. In spite of the fact that oak is being socially and ecologically valuable species, often VPs having chir pine dominated forests are economically better off than their oak forest dominated counterparts. This inconsistency is explained by the fact that income from chir-pine resin, a marketable product, outweighs what is gained (non-marketable) from ecologically important oak forests (Balooni *et. al.,* 2007). It is interesting to mention here that usually dense oak forests occurs in the areas managed by VPs. Study of VPs by Prabhakar and Somanathan (1999) showed that dense oak forests are 15.6 % more common in VP forests than the reserve forests. However, the study also shows that oak trees in VP forests too are dwindling. Thus, strengthening governance of VPs would directly result in enhanced livelihoods of the rural communities and conservation of ecologically and socially valuable forests as well in the state.

The new drive "each village has own Van Panchayat" initiated by the state government has resulted in formation of new VPs. However, the forest area under the VPs in both newly formed and old has a significant variation e.g. having an area of just 0.024 ha (Bhiru ke Aali VP in Almora district) and as large as up to 22,959 ha (Bhyundar VP in Chamoli district) indicates the glaring disparity in the size of VPs in the state. A study has estimated that for an average size household of five persons, one ha good quality forest area is required to meet their needs of fodder and fuel wood on sustainable basis. This calls for developing a rationale for determining the optimum size of a VP considering the forest type and socio- economic needs of the village communities.

A proper mechanism to ensure financial resources to VPs is required for effective forest governance in the state to build up on the existing social capital in the state for managing local forest resources even without any out side support (Box 5.1). There is limited scope for local communities to derive direct economic benefits from forests under present policy framework. However, unregulated use of forest resources in terms of fodder, fuel wood, and leaf litter (needed for preparing traditional compost) is permitted. Forest policies supporting income generation from sustainable utilization of NTFPs for local communities may minimize the chances of decline in agricultural profitability and would help conservation of forests and maintaining the flow of ecosystem services.

Box 5.1: Community Forest of Village Naugaon: An Example of Local Governance

Village Naugaon, situated near Kafra (Ranikhet Dwarahat road) in district Almora has 52 households, about 350 human and 176 livestock population. Of the 77.2 ha geographical area, nearly one-third is agricultural land and 21% common grazing land. On the rest 43% land (32 ha) villagers have developed a community forest. The annual demand of fodder for livestock is computed to 344 t Dry Matter (DM), out of which about one-third is met from agricultural crop residue, 13% from private grasslands, 39% from grazing on the village commons and remaining from the village forest. Of the total fuel wood consumption (122 t DM), two-thirds is derived from private trees/shrubs and village forest.

Establishment of Village Community Forest

Before 1920 the community wasteland in the village had a few chir pine (*Pinus roxburghii*) trees. That time the number of households was about 30 and livestock population per household was high. The livestock grazed this land year round. During summers with shortage of fodder, villagers would move with their herds in distant forests for 2-3 months. The life was miserable, particularly for women, who had to work hard and walk miles to fetch fodder and fuel wood.

The villagers felt a need to protect the village common grazing land for fodder. Way back in 1928-30 free grazing on common land was banned. One person alternatively from each household used to monitor the area to exclude grazing. Subsequently a watchman was employed with contribution from each household, initially through food grains and then in cash. Presently each household contributes Rs. 100 yr^{-1} (totaling to around Rs. 5000 yr^{-1}) is paid to watchman to discharge duties of prevention of grazing and fodder theft, fuel wood cutting, exclusion of fire, repair/ maintenance of stone wall around the community forest.

Now this erstwhile wasteland has been transformed into a well grown chir pine forest. It has approximately 10,000 big/ small trees. In addition, there are *Rhus parviflora* bushes (a high quality fuel wood) harvested at every 3-4 years interval.

Equitable sharing

Before opening the village forest for resource collection, elderly villagers assess availability of resources to fix the duration of harvest in the village common meeting. To ensure equitable distribution every year during October -November the grass harvest operation is held collectively by the community. One woman from each household harvests the grass. Two persons (one from each household by rotation) also keep a vigil on the harvesting process that allows the equitable (not selective) harvest of grass uniformly. The quality grass is evenly distributed among the fodder collectors. A designated area is fixed for each day harvest so as to minimize the wastage. All the head loads are brought to a central ground nearby and weighing on traditional balance (25-30 kg/head load) is done. The load is fixed in a manner that even children or old women can carry their share. The extra quantity harvested by the able-bodied women is excluded during the weighing process and provided to the weaker ones to fulfill the equity criteria.

Subsequently the pine litter is collected for cattle bedding. This is not weighed, but the time to collect it is fixed. It is collected in sacs/net of a standard size. Thus, everyone collects approximately the same quantity. After this, dry fallen wood is collected for fuel. Again the weighing and equity measures are applied.

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