Biodiversity in Uttrakhand Himalaya region

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Abstract: Himalaya means Abode of Snow. The Himalaya have been the supreme benefactor and protector of our country in many ways from million of years. Though youngest of the mountain chains in the world, the Himalaya have attracted tourists, philosophers, scientists and saints alike. The Uttrakhand Himalaya region provides a matchless wealth of medicinal and aromatic plants & is known to be a natural reservoir. Uttrakhand region is well known for its biodiversity. This paper aims to evaluate the present conditions of resources as a form of natural vegetation, agricultural crops, horticultural farming, herbs, tea garden practices and economic development of the Uttaranchal Himalaya. [Nature and Science. 2009;7(3):113-125]. (ISSN: 1545-0740).

Introduction

The Himalayas present a storehouse of bio-diversity, where flora and fauna vary extensively with climate diversity from one region to the other. Initially, if an attempt is made to divide the forests types based on the standard classification of tropical, sub-tropical, temperate and alpine, it becomes difficult to describe the rich diversity of the Himalayan forests. However, extensive commercial felling of forest has been reported in this region, especially in the last few decades when urban centers began to grow in areas near the forests. While the forests, farmlands and grasslands are of extreme importance for the agripastoral economy within the Himalayan region, the other renewable resource, water, has always been crucial for thickly populated plains further down in the south and east. The Himalayas has one of the highest hydropower potentials of the world, which includes three of the mightiest rivers of the world, i.e. Indus, Ganga and Brahmaputra. Besides, water resources, vast extended grasslands and dense forests in some highland parts and in the foothills of the Himalaya have certain specific advantages such as a tremendous potential for tourism. However, extreme climate variations and inaccessible terrain make it difficult to exploit and utilize all the diversified natural resources of the great Himalaya.

Forests constitute one of the most important natural resource. They play a vital role in social, cultural, historical, economic and industrial development of any country and in maintaining its ecological balance. Forests are considered not only the resource base for sustenance of the population but also as the storehouses of the biodiversity. Forests are solely responsible to maintain and improve the moisture regime and provide clear air. They moderate floods and make the streams perennial. They also produce humus and thereby maintain soil fertility. The diversity in climatic and physical setting produces a markedly diverse flora and fauna. With increasing catastrophes (mass wasting, cloud bursts, avalanches) forests have been severely fragmented at many places degraded, causing threat to local extinction to many wild species of plants.

Sustainability of forest ecosystem is an essential component of the environmental conservation efforts and any degradation of forests will have an adverse impact on various systems, such as water resources, agriculture bio diversity, environment, climate and human health, besides its impact on the subsistence living of tribal and other communities living in around forest areas. Therefore, the function with respect to conservation of soil, water, forests and biodiversity are vital for the welfare of present and future generations.

Climatic extremes like cloudbursts, hailstorms and earthquakes play a critical role as an environmental constraint. Global warming is affecting ice and glacier cover in the region. Furthermore, due to inaccessibility of the region, it is difficult to quantify and assess the damage caused by these natural events. The environmental constraints against the exploitation of natural resource also include other natural

phenomena like mass wasting, high seismic activity, landslides, glacial lake outburst floods, erosion and sedimentation.

Soil erosion is one of the major environmental constraints, which results in frequent flooding in the plains downstream and damage to agriculture, life and infrastructure. The livestock population in the region has also increased during the recent past and problem of grazing in the high altitudes has acquired serious dimension, as a result the vegetative cover is decreasing which has resulted in the loss of topsoil due to excessive erosion. The relatively soft rocks and favorable climatic conditions are the factors behind quick weathering followed Workshop on Himalayan Ecology by mass wasting and landslides. Intense monsoon rainfall also accelerates soil erosion in the region. The Himalayan rivers also carry a very heavy sediment load especially during summer and rainy season, which provides conditions for river shifting.

Cloudburst is a natural phenomenon in Himalayas and it has become frequent in the recent years. Geomorphic features like cirques, hanging valleys with broad valley, erosional glacial features with open valley on one side and dense forests especially of Oak in another side are present with average height of 5000-6500 feet. It always occurs in areas where the southern face has agriculture land. These artificial deposits are less compact, loosely laid on the surface of various types of pre-existing landforms and are prone to erosion lands transportation in bed load due to mixture of finer sand silt and coarse gravel even boulders and get a lot of direct sunlight and northern face lie behind the area and have thick forests. Cloud always move south to north in the Himalayas and when they come up against cirque like features, where the valley is closed, they become stagnant and get piled up and after some time cloud precipitate suddenly by heavy discharge in rivers and usually cause massive damage to forests and other property.

Biodiversity

Natural resources as a form of minerals and petroleum products are lagged behind in the region. Therefore, the mainland of Uttarakhand is industrially backward. Furthermore, whatever the minerals are found they are not properly mined because the fragility of terrain does not permit to do it. Heavy investment and lack of technological development, on the other hand, are making slow the process of utilization of these resources. But the availability of forests resources, wild lives, agricultural crops, extensive grasslands, varieties of herbs, flowers, fruits, vegetables, water, rearing of animals, goats and sheep is high. The feasible climatic conditions boost up the suitability for growing horticultural crops on the one hand and on the other they play a vital role for sustainability of the populace. Cultivation of fruit crops, herbs, flowers, off-season vegetables, high yield variety (HYV) of animals and tea garden practices can be improved with giving scientific inputs. Tourism can also be practiced to improve the economy and the augmentation of employment. But owing to fragility of mountain terrain and poor infra-structural facilities, these given resources of the region could not be utilized properly, particularly the forest and water resources. Now we are discussing biodiversity in Uttrakhand Himalaya in details:

Forest diversity

Among the natural resources of Uttarakhand, forests are the most important, both economically The and environmentally. The forest area is reported to be 3,466 thousand hectares and accounts for around 62.27 % of the area of Uttarakhand. The alpine and tropical rainforests that cover most parts of the state make natural habitats of some of the best-known wildlife creatures. The Jim Corbett National Park is home to Royal Bengal Tigers. Another rainforest in the region is Rajaji National Park famous for its large number of pachyderms. Alpine forests in the region include the Valley of Flowers National Park (known for its amazing variety of flowers), Nanda Devi National Park, Govind National Park and Gangotri National Park.

Uttaranchal Himalaya is very rich in forest resources and diversity. The plant diversity is found extremely rich from the valley regions to the highly elevated alpine meadows, locally known as *kharaks* or *bugyals*

The main forest types of the state according to altitude are described as follows:

(1) Deodar forests (*Cedrus deodara*)

They are found in Chakrata region, Tons Valley & Uttarkashi, and the highly elevated regions of water parting mainly Alaknanda, Nandakini, Pindar and Mandakini (1,650~2,300 m). The Deodar is a tall coniferous tree used for house construction and paneling.

(2) Blue Pine forests (*Pinus wallichiana*)

The Blue Pine is also known as *Kail*. It is found in Chakrata, Tons Valley, Uttarkashi and Joshimath areas. These are found mostly mixed with Deodar forests (1,650~2,300 m).

(3) Chir forests (*Pinus roxburghii*)
The Chir pine is found in the whole of Uttaranchal Hills. The forests exist mostly in the places of 1,000 to 1,650 m. This pine is used for making packing cases and paneling in interior decoration and also used as firewood.
(4) Teak forests (*Tectona grandis*)
The forests have been artificially planted in the *Terai* belt of the Kumaon region. The plant is a broad-leaved tree and flourishes in the plains. It is the best timber, with great demand for construction work as well as for furniture making.
(5) Bamboo forests (*Dendrocalamus spp.*)
Bamboo forests are found abundant in the Lansdowne and Kalagarh areas of Garhwal region (325~1,000 m). Bamboo is known as the poor man's timber. Its versatility of use makes it a force of livelihood for a large number of people. It is a broad-leaved species and helpful for reducing soil erosion.
(6) Oak forests (*Quercus sp.*)
Oak forests are found in the whole area of Uttaranchal between 1,325 m and 1,925 m. It is used for firewood and charcoal manufacturing. It is a broad-leaved tree.
(7) Fir (*Abies pindrow*) & spruce (*Picea smithiana*) forests
The two species of trees are found mostly between 2,300 m and 2,950 m. The forests exist in Chakrata, the Tons Valley, Uttarkashi, Pauri and Pithoragarh.
(8) Sal forests (*Shorea robusta*)
The Sal is found in the foothills of the Himalaya in *Terai* and *Bhabar* areas (500 m~1,000 m). The forests are rich in species, such as Rohini, Amultas, Kanju and Amla. Table 1 shows forest diversity based on altitude (below 1,000 m to snow line) in the State.

In the present study area, the forests are depleting at a large scale. The depletion of forests is causing severe impediments for the stability of landscape. Most of the forest patches are clearing for agricultural fields due to mounting population pressure on the hilly slopes of the state. Therefore, the rate of deforestation is high. As it is reported that the highest rate of deforestation in any biome is in tropical upland forest, i.e., 1.1% per year (FAO 1993), the similar situation is applied with the state. The people that depend on the forest for firewood are high resulting degradation of forest and deterioration of environment. A case study of the five villages is done on the bases of their elevation and distance from the road head. Per day firewood consumption (in kg) both in summers and winters is calculated as an average in the following table: Table 2 reveals that the elevation and distance form the road play a crucial role in determining per day firewood consumption in the villages. The author collected the data related with per day fire consumption and forest types after an extensive field visit and household survey with sampling method. The highly elevated villages consume more firewood than the villages in low-lying areas. Firewood consumption also depends on the availability of forestland. In the areas, with dense vegetation, more firewood is collected than that in the other areas.

Degradation of natural forests is a global problem (Guppy 1984, Sayer and Whitmore 1991). People have been destroying forests for millennia ever since agriculture was started (William 1989). In the Himalaya, deforestation is argued to be not a recent phenomenon too. It has a long history, being well established in late eighteenth century at least (Mahat *et al.* 1986). The heavy pressure of population on the agricultural land due to high growth rate of human population compelled the inhabitants of the region to solve the problem through merging forestland either for settlement or for agricultural practices. However, the extent of impairment of various processes attributed to vegetal degradation depends upon the range of other factors including past histories, intensity of removal of natural vegetation, patterns of natural regeneration and /or other human interferences (Valdiya and Bartarya 1989 & 1991, Gilmour *et al.* 1989, Ramakrishnan *et al.* 1992, Alford 1992).

The management of the forest resource in the mainland of Uttaranchal is getting setback due to two reasons: first, an inaccessibility of the temperate forestland and second, the depletion of forest in surrounding of settlements. The instability of the land due to natural phenomena (terrestrial and atmospheric), such as slope failure, landslides, mass movements and rock fall, further accentuate the problem of depletion of forest. There may be two solutions for sustainable management of forest resources. (i) The proper utilization of the waste woods, which are found in the inaccessible areas of the region through small-scale village based forest industries. That will help the economic development of the region as well as the sustainable livelihood of the populace there. (ii) Afforestation, around the settlements and the areas, where soil erosion is more prone, should be done to stabilize hill slopes.

Agricultural diversity

Agriculture is the main stay of the people of Uttrakhand. Of the total population, more than 75% people are engaged either with the main occupation of agriculture or its allied practices.The study on agriculture in Uttarakhand State demands better planning separately for the mountainous mainland and foothill plains. The prospects of agriculture development in the hill region of uttrakhand appear very limited due to a number of constraints imposed by the natural environment. In this region, which is predominantly agricultural, population pressure has far exceeded the carrying capacity of the land and it, therefore appears imperative that the economy be supplemented by activities allied to agriculture such as vegetable growing, horticulture, bee-keeping, poultary farming, dairy farming etc.Which should, in a phased manner, become vital components of the rural economic structure- as per environmental conditions and needs of the village people. In the mainland of Uttaranchal, traditional subsistence agriculture is dominant in farming system. But their viability in terms of sustainable livelihood is insufficient. Therefore, the rate of out-migration from the region is high. Among the principal crops rice, wheat, millets, barley, pulses and oil-seeds are grown in the entire state. The ratio of pulses and oil seeds is comparatively low. Fortunately, the state has high diversity in food grains, vegetables, fruits, oil-seeds and pulses in all the altitudinal climatic zones, such as tropical, temperate, and cold. The feasibility of climatic conditions and diversity in crops may help for sustainable farming. Wheat occupies highest percent (33.54%) in the total sown area, followed by rice (23.51%) and millets (12.76%). Cultivation of vegetables is extending and now accounts for 12.45% of the total cropped area of the state. The economic viability of off-season vegetables, pulses and oil-seeds in the farming system of the state is noteworthy while the cropped area with these crops is very small. The area with off-season vegetables can be raised for sustainable livelihood because the environmental conditions are very suitable for this production.

Biodiversity of medicinal and aromatic plants

Ayurveda has prospered in the laps of Himalaya and as such herbs growing here find high place in the Ayurvedic texts. It is an accomplished fact besides medicinal plants, Himalaya are the home of many species of aromatic nature.

Medicinal Plants

In India, there are about 3,000 medium to large scale drug manufacturing units which utilize several drug plants, both from cultivated as well as wild sources, as raw materials. Whereas bulk of this raw material is obtained from forest, only a few plants are under systematic cultivation. Despite the close relationship between the forest and pharmacy, very little efforts have been made to maintain, manage and develop the drug plant resources of the Himalayan forests.

At present there is neither any organization to estimate productivity of even selected forests at regular intervals nor has there been quantitative assessment of the growing stock of any of the crude drugs/medicinal plants. Obviously, it would be hazardous to make estimates of even more valuable medicinal plants growing wild in the forest or annually collected in the Himalayan states. It is known that about a thousand of plant species distributed in various climatic zones in India are found to have medicinal virtues but only a handful of these are commercially collected for use within the country and for exports.

Table 1 describes the important/major chemical constituents/active principles of some commercially important medicinal plants, traditionally collected from the Himalaya, which would provide a glimpse of a wide variety of the medicinal plant components of the Himalayan forests.

Table 1: Commercially important medicinal plants from forests

Plants	**Chemical constituents**
	Active principles
Bantalnag	Aconiting, chasmacontine
Aconitum chasmanthum	Chasmonthine

Aconite/Atis	Atisine, heteratisin &
Aconitum heterophyllum	hetisine
Bach	Asargone
Acorus calamus	
Vasaka	Vasicine & Vasicinone
Adhatoda vasica	
Kirmala	Santonin
Artemisia maritima	
Safed Musli	Asparagin
Asparagus adscendens	
Nim	Nimbin, nimbinin, nimbidin,
Azadirachta indica	Azadirachtin, salannin
Rasaut	Berberine
Berberies aristata	
Pashanbed	Sitosterol, bergenin
Bergenia ciliata	
Amaltas	Fosticacodom, rhein,
Cassia fistula	Sennoside A & B
Brahma manduki	Brahmoside, brahminoside
Centella asiatica	Asiatic acid
Hirantutiya	Colchicine
Colchicum luteum	
Satpura	Daphnin
Daphne papyracea	
Dhatura	Scopolamine, hyoscyamine
Datura metel	Atropine
Dhattura	Atropine, hycocine
Datura stramonium	Hyoscyamine
Kins	Diosgenin
Dioscorea deltoidea	

Ephedra	Ephedrine
Ephedra nebrodenis	
Sankhapushpi	Betaine, evolvine
Evolvulus alsinoides	
Kotu	Rutin
Fagopyrum esculentum	
Kutki	
Gentiana kurroo	
Kalihari	Chelidonic acid, colchicine,
Gloriosa superba	lumicolchicine
Kurchi	Conessine, holarrhimine
Holarrhena antidysenterica	Kurchine, conarrhimine
Jatamansi	Jatamansone & jatamansic
Nardostachys jatamansi	Acid
Nandru	Hyoscyamine & hyoscine
Physochlaina praealta	
Kuru	Picrorhizin, kutkin
Picrorhiza kurroa	
Papra	Podophyllin, podophyllotoxin,
Podophyllum hexandrum	Podophyllic acid
Rhubarb	Emodin, physcione, chrysophanol
Rheum emodi	
Chiraita	Ophelic acid, chiratin,
Swertia chirata	Amarogentin
Jangli Piyaz	Scillarens A & B
Urginea indica	
Banafsha	Rutin, cyanin, methyl
Viola odorata	Salicylate, odoratine
Ashwagandha	Withasomine, withaferin
Withania somnifera	A & withanolide

The trade in crude drug in largely unorganized and statistics on their production and utilization are generally not available. Medicinal plants/crude drugs are good foreign exchange earners. To boost indigenous production and to avoid imports of crude drugs, the cultivation and exploitation of indigenous and exotic medicinal plants should be encouraged in the national afforestation programmes, such as Social Forestry, Farm Forestry, etc.

Aromatic Plants

Himalaya are repository of many aromatic or essential oil bearing plants and it is difficult to enumerate their entire wealth. However, the present review gives the status of some important aromatic plants which need the attention to explore different fields, so that the scientists may be able to deal with the species judiciously and the entrepreneurs may exploit them according to the need of the trade and industry.

Table 2 highlights the commercially important aromatic plants for their essential oil value in our country. The essential oil contents of these plants compare well with those plants grown in other parts of the world and commercial exploitation of these plants is feasible which can meet the requirement of various industries, viz, perfumery, cosmetics, soap, toilet, hair oil, pharmaceuticals, food, alcoholic beverages, etc.

Table 3 includes such aromatic plants which occur locally in the Himalaya. These do not either occur elsewhere or have not so far been exploited commercially. In nature, yield of essential oils from these species is however, low but their production can be increased by suitable cultivation techniques and proper methods of exploitation.

Table 4 consists of some lesser known aromatic plants of Himalaya and recent investigations have explored the possibility of their commercial exploitation while a few species though known need proper attention.

The value of essential oils obtained from various aromatic plants (Tables 2-4) lies in the presence of certain commercially important components or chemical constituents which suggest their industrial utility. It has been assessed that the aggregate value of essential oils used in processed food, toilets, cosmetics and pharmaceutical preparations is around Rs. 300 crores. Their demand is going to increase four times by the end of this century. Essential oils are good foreign exchange earners too involving low transportation cost. Attempts should, therefore, be made to explore the new possible species having essential oils and to grow them in suitable areas so as to meet national demands, boost exports and avoid imports.

Table 2: Commercially exploited aromatic plants of Himalayas

	Plants	**Chemical constituents**
1.	*Bach* Acorus calamus	Asarone, calamenol, calamene
2.	*Bel* Aegle marmelos	L-phellandrene, citronellal, para-cymene, citral
3.	*Angelica* Archangelica	L-pinene, phellandrene, osthole, terpenes & sesquiterpenes, L-phellandrene, para-cymene
4.	*Chura* Angelica glauca	L-pinene, L-phellandrene, Selinene, L- cadinene
5.	*Zira* Carum carvi	Carvone, a terpene & traces of carvacrol

6.	*Tej Pat* Cinnamomum tamala	Cinnamic aldehyde, linapool
7.	*Ferula* Jaeschkeana	Azulenes, pinene, cadinene
8.	*Aaraar* Jumiperus communis	Friots, pinenes
9.	*Dunp* Juniperus macropoda	Cedrol, Iimonene, 4-terpineol
10.	*Jatamansi* Nardostachys jatamans	Jatamansone & Jatamansic acid
11.	*Kuth* Saussurea Lappa	Dihydro costus lactone, costunolids,costol
12.	*Ner* Skimmia laureola	Linalyl acetate, linalool
13.	*Stinking Roger* Tagetes minuta	Aromadendrene, tagetone
14.	*Banajwain* Thymus serpyllum	Carvacrol, para-cymene, gama-terpinene
15.	*Tejbal* Zanthoxylum alatum	L-phellandrene, traces of linalool, a sesquiterpene
16.	*Indian lichens chrilla* Parmelia nepalensis, P. nilgherrensis, Ramalina sub- complanta & Usnea lucea	Resinoids

Table 3:Commercially unexploited aromatic plants of Himalayas

	Plants	**Chemical constituents**
1.	Artemisia dracunculus	Methyl-chavicol & paramethoxy cinnamaldehyde
2.	Chaerophyllum villosum	L-pinene, car-3-ene
3.	Elsholtzia pilosa	1-8 cineole, terpinyl acetate limonene
4.	Heracleum canescens	Pinenes, L-terpinene, phenylethyl acetate

5.	Heracleum candicans	Pinenes, dihydro-carveol, carveolacetate
6.	Pushkar Inula racemosa	Alantolactone, isolantolactone & sesquiterpenes
7.	Zufa yabis Nepeta ciliaris	Tricyclic sesquiterpene, pinocarvone, L-Pinene
8.	Billilotan Nepeta hindostana	Limonene, citronellal, geranyl acetate, citronellol
9.	Komal Prangos pabularia	Myrcenae, camphene, L-pinene, osthole, 4-Camphene, borneol

Table 4: Lesser known aromatic plants of Himalaya

	Plants	**Chemical constituents**
1.	Caucalis anthriscus	Benzyl alcohol
2.	Rangchari Elsholtzia polystachya	1,8-cineole & 2- subsituted furan derivatives
3.	Sitruti Hedychium spicatum	Ethyl ester of p-methoxy cinnamic acid
4.	Ligusticum elatum	Pinenes, sabinene, car-3-ene
5.	Lavangalata Luvunga scandens	Cineole, methyl cinnamatem & sesquiterpenes
6.	Sathra Origanum vulgare	Pinenes, dipentene, linalool, sesquiterpenes
7.	Kheshavo Selinum tenuifolium	Limonene, elemol, terpineol, geraniol
8.	Moor Selinum vaginatum	Pinenes & limonene
9.	Vanayamani Seseli indicum	Limonene, selinene
10.	Bhootakeshi Seseli sibiricum	Pinenes, myrcene, p- cymene, β-pheldandrene

Considering the economic value of the components of aromatic plants in each group, it may be necessary to grow them according to their industrial demand. Since methods of cultivation and exploitation of most of the aromatic plants have not been perfected, it may be useful to conduct agronomical trials before establishing a particular crop. Determination of optimum stage and season of harvesting is also essential to obtain good quality product with maximum yield. Cultivation, recovery of essential oils and isolation of their components from aromatic plants is labour intensive and generates lot of employment also. Therefore, introduction and growing of aromatic plants in forest areas, or in crop rotation with agriculture crops in Agro-Forestry Programmes, or as rehabilitation crops in Social Forestry Programmes is in the interest of national development and is likely to fetch very good returns. Based on these considerations, significant advantage can be obtained from the aromatic plants. With this in view, a list of species which should receive attention in Himalayan region are highlighted in three groups. The presence of various constituents are also indicated against each species which are suggestive of the scope of utilization by different industries for flavouring foods, drinks and alcoholic beverages, perfumery, cosmetics soaps etc.

Uttarakhand is a storehouse of a rich variety herbs and medicinal and aromatic plant species. The Government intends to exploit this advantage. Special emphasis is on R&D.

• An integrated action plan has been drawn up for this purpose in coordination with the Government of India and other concerned agencies in the State and elsewhere in the country.

• R&D in the area of Medicinal Plants and commercial production of applications and formulations will be developed in conjunction with Research Institutions and reputed companies.

• A Medicinal and Aromatic Plants Export Zone has been set up covering seven districts of Uttarakhand and Specialized Herbal Parks are in the offing.

Medical and health care

The salubrious climate, pollution free environment and the availability of a wide range of flora and fauna in the mountainous terrain, make Uttarakhand an ideal location for developing centres for alternative medicine and health care facilities. Possibilities of establishing gyms, sauna and related facilities, which would motivate health care enthusiasts exist in plenty.

Forest product- Herbs and spices

A significant portion of Uttarakhand is under forest cover (almost 70 percent). There is, thus, excellent potential for the development of forest resources based Industries in the State. In addition, there is ample scope to develop industries based on forest and agro-wastes such as lantana, pineneedles, plant and vegetative fibers such as Rambans, etc.

Horticulture and flouriculture

Uttarakhand has almost all the different Agro-geo climatic zones making it particularly conducive to commercial horticulture and floriculture. Horticulture schemes are being promoted in a big way through adequate incentives and facilities. Given the constraints on the productivity of field crops, a shift from the cultivation of low value field crops to high value crops, such as fruits and vegetables appears to be the most obvious option in the state. The Uttarakhand region has proved to be suitable for growing different types of temperate, sub-tropical and tropical fruits. Also, the region has wide scope for growing different kinds of vegetables, flowers, ornamental plants, mushrooms, and medicinal plants in its different climatic zones. Temperate fruits, such as apple, pear, peach, plum, apricot, cherry and walnut, are grown in the places of 1,000 m~3,000 m (Sati 2004). The places from 300 m to 1,400 m are planted with citrus, mango, litchi, banana, guava, papaya, strawberry and different vegetables and crops. Market forces and institutional set-up created for gearing horticultural development led to economic growth but at the cost of equity. Prosperous farmers benefited more than small and marginal farmers (Swarup and Sikka 1987).

The land under fruit cultivation is 190,192 ha and under vegetable 80,332 ha, accounting for 29% and 15% of the total area sown, respectively. The total production of fruits and vegetables in Uttarakhand is estimated to be 345,339 metric tones and 492,785 metric tones, respectively according to data available in 2003. Apple is the most important among the various fruits grown in the region and its cultivated land is 54,000 ha.

Among vegetables, potato is the most importance crop. In the state fruits are grown in the different altitudinal zones, and among them apple, peach, citrus, mango, plum, apricot, walnut, litchi and other fruits are important. The land used for production of various vegetables in the region was almost twice increased

and their production was increased by 2.5 times during the past two decades. This clearly indicates that growing of fruits and vegetables has spread over larger areas of land. However, lack of proper marketing facilities, and absence of post-harvest technologies and storage are serious constraints to a more rapid and systematic development of fruit and vegetable cultivation and marketing in the region. Cultivation of off-season vegetables in different altitudinal zones of Uttarakhand in summer offers extensive market (Mehta, G. S. 1990).

Herbs are naturally grown in the meadows *(kharaks*). Fortunately, the state has extensive meadows along the Great Himalayan Ranges. These herbs are locally utilized for medicinal purposes with the positive results. Simultaneously, a tea garden practice is centuries old, but presently its extension is available in very limited areas. Following the creation of Uttarakhand State, the government has launched the scheme for establishing tea gardens in different geographically suitable areas.

Floriculture is being developed in a big way in order to supply the domestic market and penetrate foreign markets. Floriculture can help generate employment opportunities as well as augment incomes of farmers. The climate being ideal for growing flowers nearly round the year it is proposed to establish Floriculture Parks with common infrastructure facilities for sorting, pre-cooling, cold chain, processing, grading and packing/marketing facilities.

Agro and food processing industries

The Uttrakhand Government will assist in establishing small & medium size Agro Parks, Food Parks etc., which will provide common infrastructure facilities for storage, processing, grading and marketing, thus ensuring that surplus fruits and vegetables do not go waste as at present. Four Agri Export Zones have already been declared under the AEZ scheme of the Government of India for Leechi, Horticulture, Herbs, Medicinal Plants and Basmati Rice(Maikhuri, R.K, et.al 1995). Further, efforts will continue to promote production for export and provide access to domestic and export markets for products from the State. Uttarakhand has been included in difficult area category by the Ministry of Food Processing Industry (MFPI), Government of India and hence units being set up in Uttarakhand will be eligible for higher incentives under the schemes of MFPI. The State Government is also providing matching subsidy for projects under various schemes of Agricultural & Processed Food Products Export Development Authority (APEDA), National Horticulture Board (NHB), Ministry of Food Processing Industry (MFPI) and the Natural Medicinal Plant Board (NMPB) subject to a maximum limit of Rs. 20 lakhs.

Biotechnology

Biotechnology (BT) is poised to make significant contributions in agriculture, human and animal health care, environment management and process industries. Rare species of plants and animals found in the Uttrakhand state, add to its natural advantage in this sector. In this context, a MOU has already been signed between Rabo India Finance Company, Infrastructure Development Finance Company and the G.B.Pant University of Agriculture and Technology in order to forge strategic cooperation to jointly pursue initiatives in the sphere of research in food and agriculture sectors. A high level Biotechnology Board is also being setup under the Chairmanship of the Hon'ble former Chief Minister N. D.Tewari.

Eco-tourism

The Uttrakhand region, with its lofty mountain peaks and glaciers is the source region of many important rivers of North India. The region also abounds in a vast range of natural phenomena including glaciers, waterfalls, lakes, winding river valleys and mountain slopes showing a wide variety of flora and fauna. The entire region, therefore, presents an endless variety of scenic beauty and it may not be an exaggeration to say that the Himalaya is one of the most picturesque mountain systems of the world (Joshi S.C,2004). The hills of Uttaranchal have all the ingredients for adventure packed with excitement and thrills - an unexplored valley, towering peaks, flowing rivers, snow-capped mountains, a splendid combination of flora & fauna and vast tracts of virgin snow. Mountaineering, trekking, skiing, river rafting, canoeing, kayaking, fishing, angling, aero sports - there lies a whole world of activities to satiate the wildest of sprits. Bhagirathai, Chowkhamba, Nanda Devi, Kamet, Pindari, Har ki Doon, Dayara, Kafni, Auli, Munsyari, Pauri, Pithoragarh, Kodiyala are some of the hotspots where adventure seekers can have an experience of a lifetime. Uttaranchal also treasures some of the most breathtaking destinations for Wildlife Tourism - presenting a perfect retreat for picnics and excursions.The snow-capped mountains, Rolling Meadows, high-altitude lakes and dense forests in the hills of Uttaranchal support exotic wildlife, bird life and plant

life. These wonderful creations of nature add a dash of splendour to nature's abundance that exists in the environs of the Uttaranchal. Some National Parks and Sanctuaries are created to preserve this gift of wildlife and enable visitors to have a privileged view of the same – Corbett National Park, Rajaji National Park, Govind Wildlife Sanctuary, Nanda Devi National Park and Kedarnath Sanctuary. In the wilderness of these Parks and Sanctuaries animals like tiger, elephant, leopard, leopard cats, jungle cats, fishing cats, snow leopard, panther, snow cock, tahr, musk deer, chitals, barking deers, sambar, Himalayan black bears, brown bears, bharals, monals, crocodiles, gharials (descendants of the prehistoric reptiles) can be seen along with many species of birds, butterflies and snakes. Uttaranchal, a land resplendent in awesome natural splendour is a jewel of the glittering Himalayan necklace. In its range of natural beauty, Uttaranchal is known for White Mountain peaks, blue ribbons of meandering rivers, eye-catching pink and red rhododendrons and birds of vivid plumage. From the most modern facilities at Mussoorie, Narendranagar and Nainital to the untouched and pristine beauty of its snow-clad peaks, rivers and forests, Uttaranchal is indeed a paradise for tourists.

It can be *concluded*, the future prospects of the available resources for sustainable development of the state are as follows:

(1) Horticultural Development, in this context, offers significant scope and could become a lead sector in many parts of Uttarakhand, particularly in the low hills and middle mountains. As indicated earlier, a variety of fruits are grown in the region during different crop seasons.

(2) A large variety of minor forest produce, medicinal plants, and natural fiber plants found across the region, and these could be harnessed advantageously to produce useful and high-value items.

(3) Promotion of ringal (bamboo) plantation in larger uncultivable areas and its use to make useful marketable products could thus be both economically and environmentally profitable. In some relatively high altitude areas, the production of ringal-based goods could become an important economic activity. There is ample scope for developing this activity for larger markets, both for creating gainful employment opportunities for the local population and also for the protection of the environment, as it has also been recognized as a plant that binds the soil, thus preventing soil erosion and landslides.

(4) Rearing sheep and goats have special advantages in the hills and mountains at altitudes of 700m and above. It has been a traditional activity of the Bhotia households in high altitude areas of Pithoragarh, Almora, Chamoli, Uttarkashi and Dehradun districts. The Animal Husbandry Department of the State Government is involved in improving the breads of sheep in order to increase the production of better quality wool in the region.

(5) Woolen industries have been given significant importance during the recent past. A greater segment of the population, particularly women and relatively low-income groups, is participating increasingly in the production of woolen items as a part-time or full-time activity.

(6) Tea garden practice is centuries old but presently its existence is very less. This practice will definitely help for economic development of the region.

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