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GIS APPLICATION FOR MOUNTAINOUS TERRAINS: SOME CONSIDERATIONS AND OPTIONS

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INTRODUCTION

Mountains are areas of high relief having distinct changes in terrain slope and thus require a three-dimensional representation for spatial modeling. Maps and GIS in general treat the world as if it were flat (plain land), this two-dimensional view leads to incompatibility in appropriateness of GIS application between that for plains and mountains. Mountains have some very specific features that need to be considered during spatial analyses. These are slope, elevation, aspect and their degree of heterogeneity. Unfortunately it is not the practice, apart from few modifications made in GIS applications for mountain areas. The study illustrates integration of such factors in ecological zoning, land suitability classification and probability mapping, such as for land erosion. 'Agricultural suitability' and 'Vulnerability to land erosion' maps of Pranmati watershed.

Maps represent geographical area on the planar surface whereas due to slope differences in the mountains the actual surface area is greater, the discrepancy in area calculation leads to overestimation of population density (biotic). A watershed, having modal average slope in 20-25° range, has geographical area of 94 km² as against the actual surface area of 105 km². A large surface with very steep slope is reduced to negligible area on a map. Similarly linear calculations and buffering becomes erroneous for mountains using simple GIS techniques. Shorter distances than actual are recorded from the maps, such errors could lead to underestimation in the cost of road construction. Pronounced slope and shadow effect cause much problem in interpretation of remote sensing image data. In the mountain areas, research is still needed on how to use shadow information (total shadow minus topographically caused shadow) for land cover classification. Thus GIS has an important role in improving digital image processing in mountain areas.

Thermal differences due to aspect affects the limits of flora and fauna distribution. It is well known that the upper limit of any vegetation type is bound to be lower on the northerly aspects in the northern hemisphere and potential-evapo-transpiration rates are higher on the southern aspects making them drier. Such factors were used in the bio-climatic zonation in our study.

Aspect can be used to our advantage in conjunction with geological structure to assess the trend of rock beds, which may be useful for planning of roads and other constructions. This approach was adopted in the finding causes of landslides near Joshimath and also in the assessment of the proposed road in Pranmati watershed. Use of GIS in landslide hazard zonation is new field that is being focused in various parts but none have been quite comprehensive. Inversion of temperature is another phenomenon dictating the land use in valley bottoms. Townships generally prefer ridge top locations, as valley bottoms are colder at night and foggy. Accessibility is not easily defined in the hills as in plains and this is an important factor for land use and infrastructure.

Spatial complexity of mountain regions makes extrapolation very difficult. The same locational theories for the hierarchical distribution of settlements do not apply to these regions as in the plains. The complex interaction between various factors lead to this heterogeneity. Added to these are the irregularities of data and difficulties of data collection and fieldwork in these areas.

So far there are two approaches developed towards modeling the three-dimensional complexity of the mountains, these are the DTM approach and the Landscape approach. The mountain scientists require a truly 3D GIS. However, incorporation of the approaches into knowledge based GIS is yet to be developed. Digital terrain models (DTM) helps in portraying the three-dimensionality of the mountains, but overlaying procedures on DTM are yet not satisfactory. Better use of aerial photography is called for

in this field. Global Positioning Systems (GPS) is being used with GIS for mapping new (unmapped) features. With DTM, GPS and appropriate weightings attributed to slope, aspect and elevations in GIS it is possible to improvise the present inaccuracies of GIS applications for mountain regions.

In recent years, the growing concern over the environmental degradation of mountain ecosystems has gradually placed mountain issues in environmental and political agenda (Heywood *et al.*, 1994). An example of this growing interest was the formulation of a Mountain Agenda for the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro during June 1992 with the goals of: (a) making an authoritative statement on the environmental status and development potential of the world's mountains; (b) disseminating this information in the widest possible form; (c) publicizing the urgent need for priority ranking of the mountain problem; and (d) providing some guidelines for a practical response to the problems and challenges of the mountains for consideration by world leaders (Ives, 1992). All these broad goals require information, as recognized in Chapter 13, on 'managing fragile ecosystems: sustainable mountain development,' of Agenda 21, and this can be seen as the basis for promoting wider use of GIS for assist in understanding the mountain environments (Heywood *et al.*, 1994). Several organizations are developing regional and national scale monitoring programmes in which GIS plays a central role. Hence it is very important to assess the applicability, or degree of accuracy in such GIS applications. Heywood *et al.*, (1994) underestimated the uniqueness of GIS application in mountain environment, stating, "that there is nothing unique about the character of GIS applications in mountain areas" although they add "nevertheless, the use of GIS in mountains require some special considerations".

The primary criterion that distinguishes mountains from other land surfaces is its significant positive relief. Slope, aspect, complexity and heterogeneity of climatic, vegetation, faunal and land use distribution patterns are all outcome of this primary factor, relief. The paramount effect of relief is nowhere more spectacular than in the Himalaya, and this is where our study is based. The physical characteristic that best defines mountains is their three-dimensionality. It is this three-dimensionality that poses the greatest challenge for modeling these regions using GIS, for the simple reason that most GIS and the data they incorporate still treat the world as if it were flat. GIS applications started in the West and gradually, through government or semi-government organizational aid and private enterprises, spread to the East. In India, particularly in the mountain areas the use of GIS has been mainly organizational. Therefore the fields of GIS application here have been land use analysis, hazard assessment, natural resource management, visualization of terrain, ecological and hydrological modeling *etc.* Most of the work has been application of conventional GIS methods without much thought to the effect of relief and probable errors. The sphericity of the earth has long been recognized and assigned a role in geography but the topological nature of the surface has not received as much attention (Coffey, 1981).

This paper deals with the source of errors encountered in GIS application to mountain environment using examples from some case studies and references. The paper also goes further to evaluate some of the options for improvising GIS applications for mountain areas.

Errors in GIS applications for mountain environment

"Error and uncertainty are common features of cartographic information, so it is hardly surprising that these aspects are also present in digital version of analogue maps" (Openshaw *et al.*, 1991). GIS is a powerful tool in spatial analysis and its power is obvious in that it has the potential to dramatically increase both the magnitude and importance of errors in spatial databases. Burrough (1986) identifies 3 main groups of factors that govern errors that may be associated with spatial data processing. These are: (a) obvious sources of error (human); (b) errors arising from natural variations or from ordinal measurements; and (c) errors arising through processing.

The errors associated with GIS applications specific to mountain regions, which we are concerned with here, are from the second group. No map is entirely error free but errors due to natural variations in mountainous terrain becomes significant. Positional error, aerial interpolation error and linear measurement error are increased on sloping terrain.

Error in area calculation: Calculation of population density (of vegetation) is exaggerated by underestimation of area for the sloping terrain. The actual surface area on a sloping terrain is greater than

the geographical area depicted on the map that represents the surface of the earth as a flat surface. The actual area is the product of the geographical area and the *Cosine* of the average slope angle of the place. The smaller the unit size the greater the accuracy (Figure 1).

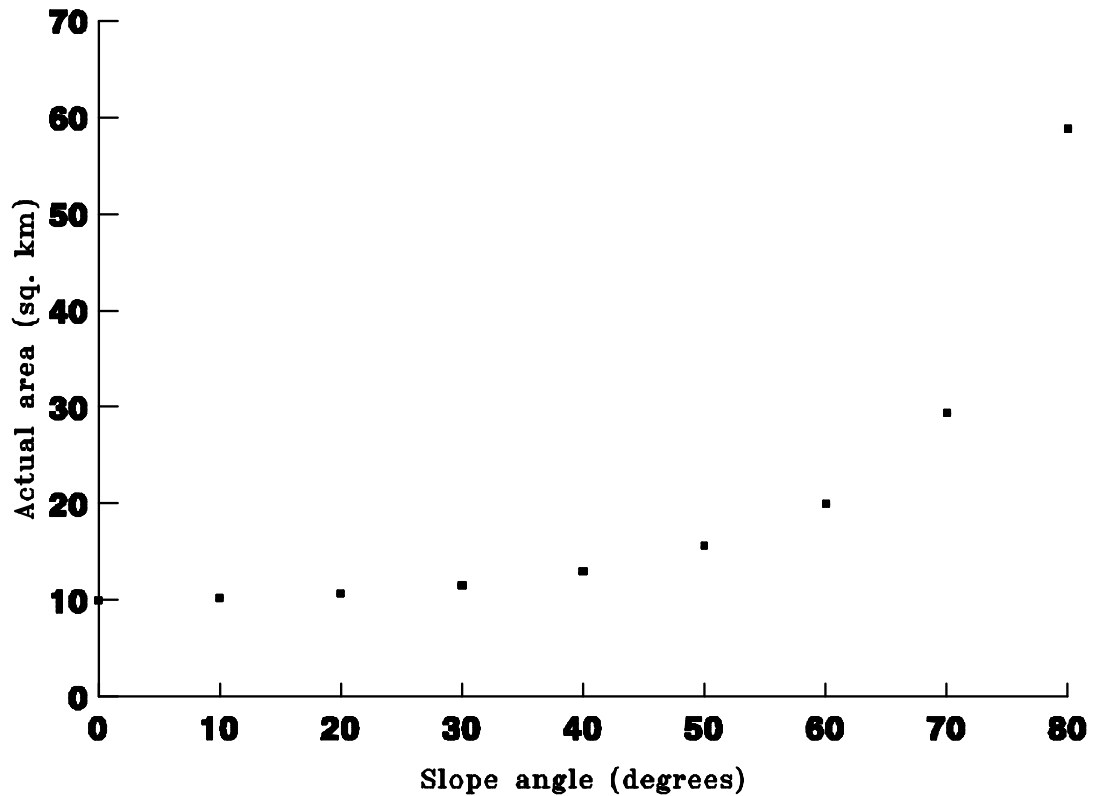


Figure 1. Discrepancy between actual area and geographical area depending on slope of land.

Error in linear calculation: Similarly the linear distances over sloping land are greater in reality than depicted on the maps. The actual distance in this case can also be calculated by finding the product of the mapped distance and the *Cosine* of the average slope angle traversed. Thus distances derived from GIS give wrong messages, such as shorter road distances and lower drainage density. As a result cost deduced for transmission line or road construction would be an underestimated value. Indeed the difference would not be very large.

Positional error: As a result of shorter distance derived from GIS for a mountainous terrain, the placement of points according to linear measurement becomes erroneous when applied on sloping terrain. For example, if sampling points is to be located 1 kilometer from a given point and their positions are worked out with GIS considering a 2 dimensional surface the resultant position would be further away than 1 kilometer due to the slope involved. For that matter how would the measurement of point patterns be carried out using nearest-neighbour analysis or quadrant sampling for mountain areas? Such questions become more relevant as detailed GIS analyses are being carried out on larger scale maps.

Buffer zone error: Since linear distances are underestimated a buffer zone generated by GIS that ignores the land slope would enclose a wider area than actually intended. The proportion of additional distance brought into the buffer zone would be directly proportional to the slope angle of the land.

Ineffectiveness of straight-line accessibility derivation: In plain land accessibility is derived simply by multiple buffer generation from the road (line) for an area and from a settlement center (point) for evaluating accessibility of a village to different service centres. This simple method does not hold true for mountain regions, where slope and other physical impediments must be taken into account when working

in scales larger than 1:50000. Some accessibility maps have been made taking the contours into consideration (Bournay & Pradhan, 1994; Trapp, 1995) but existence of un-traversable slopes do not seem to have been considered. Accessibility passages only come below 40° slopes for foot tracks and within 10° for motorable roads. Therefore the algorithm for accessibility mapping in mountain areas needs to be far more intricate.

Veregin (1995) very well defines the types and sources of error. "Errors result from inadequate data acquisition methods that do not truthfully capture the real world phenomena. This conceptualization has much in common with statistical treatment of error in terms of bias and precision... That is, encoded values represent approximations... Error can therefore be reduced through the use of more refined data acquisition techniques ... and methods of repeated sampling". Apart from this is the inherent variability of geographical phenomena. Veregin (1995) states that in case thematic attributes, methods for measuring and documenting error can be differentiated in terms of the scale of measurement as appropriate, whereas for interval and ratio data, error can be measured in terms of the mean deviation between actual and observed values at a sample of locations. This provides an error index analogous to the root mean squared error (RMSE) for elevation data.

Effect of Slope factor

Although for most purposes, the earth may be regarded as a uniform surface, it does have local variability in its relief. Similarly, any conceptual surface may be examined in terms of its degree of relief. Relief is commonly expressed by the concept of gradient, which identifies the change in the vertical dimension as the horizontal dimension changes (Coffey, 1981).

The difference in area calculation does not affect land use issues since land revenue measurements only consider horizontal land surface, and for all practical uses (house construction, agriculture, tanks) a quasi horizontal land is put to use. Vertical component of the land is not utilized. However, for forest cover the actual perimeter and land surface is kept in record that does not match (is greater than) the geographical area depicted on the map. Therefore when a forest area is delineated in GIS its area is underestimated. The problem becomes acute in the case of cliffs or very steeply sloping land that may be the habitat of particular plant species.

In Pranmati watershed, while analyzing the land use changes, it was observed that the new agricultural extensions during 1963 to 1993 were predominantly (26.5%) on the 20-30° average slope areas since the lower slopes were already under cultivation and higher slopes are not preferable.

Effect of topographic aspect

South facing aspects in the northern hemisphere is sunnier (receiving longer period of solar radiation), and therefore warmer and drier. As a result the upper limits of occurrence of any fauna or flora is higher on the southern aspects than the northern aspects. Even the snow line is lower on the northern aspects and the snowmelt regime too is different. The southern aspects being sunnier and warmer have less forest cover and are preferred for agricultural purpose, whereas northern aspects are more forest clad. Such is the impact of aspect on the local moisture regime. Therefore aspect must be considered along with edaphic, macro-climatic and infrastructural factors in land use planning for such areas. In our study for the Pranmati watershed the agro-climatic regions were defined taking into consideration both elevation and aspect, and based on that the land suitability classification was carried out. Agricultural extension during 1963 to 1993 was mainly (28%) on the southwestern slopes and eastern slopes, and marginal on the northerly slopes. There was less extension on the south facing slopes due to non-availability. In soil fertility evaluation study slope and aspect derived from DTM have provided two of the extrapolation factors in soil carbon and nitrogen contents (Schmidt, 1991) mapping.

The same geological structure has different facet according to the aspect. A northeast dipping rock strata has dip slope on the northeast aspect and anti-dip slope on the southwest aspect. This fact has significant implication on slope-cut road construction. Consequently the anti-dip slope with inward sloping rock beds provides a safer side for road construction, as dip slopes would be more prone to slope failure. In the Himalayas, where due to thrusting the general orientation of rock strata is uniclinal, this method is applicable. This rule was applied in our study, in combination with lithology and structure, in

the Garhwal Himalayas for finding the causes of landslides south of Joshimath and assessment of the proposed road in Pranmati watershed, north of Tharali. In case of Pranmati watershed the general dip direction is 30° E of N at 45 to 60° slopes, and the proposed road is mostly on the right bank of Pranmati Gad, traversing unsafe dip slopes where the result of the slope cut for road construction will be rock slip and slumping, only 20% of the proposed route is on comparatively safe slope for road construction where the rocks dip away from the road cut. Moreover the proposed road traverses a major active landslide. Re-routing the road on the anti-dip slopes as much as possible and using dip slopes only where the surface slope all over is less than 30° is recommended. In Joshimath area, rather than a correlation with dip and anti-dip slope the landslide frequency has relation with the lithology and the effect being enhanced in road-cut slopes. Here landslides are found to be aggravated (larger and active) where intersected by roads.

Heterogeneity of mountain landscape

Mountain ecosystems are very heterogeneous in the spatial distribution of any feature, therefore inter-, or extrapolation leads to erroneous results. Extrapolation can be very risky without deep understanding of the inter-relationships of the variables involved in the extrapolation, and the risks of inaccurate or improbable extrapolation increase with the number of variables and the complexity of the environment. The data for almost all aspects of mountain ecosystems are very heterogeneous in their length and frequency of record, spatial coverage and availability. The three-dimensional complexity of the mountains can exacerbate these problems to an extreme extent (Heywood *et al.*, 1994).

Data sources and related problems in mountain areas

The main data sources for mountain regions are similar to that of the lowlands but due to its inherent heterogeneity higher resolution of remotely sensed data and greater sampling density for ground truthing is necessary. One new and reliable source of digital locational data is from Global Positioning System (GPS). GPS is particularly helpful in representing break line features characteristic of mountain areas. However, locking-on at least 4 satellites in mountain terrain are often problematic when working in confined areas, such as deep valleys (Stocks and Heywood, 1994) so GPS may prove to be not so effective in certain areas.

There are some inherent problems related to mapping from remote sensing and aerial photographs. Geometric distortion arises when either an aerial photograph or a satellite image is used to record a mountain region. The displacement between observed and true map locations of ground feature has been estimated as ± 9 pixels, *i.e.*, ± 270 m for pixels with a resolution of 30 m (Hill & Kohl, 1988). Fukushima (1988) cites root mean square (RMS) errors of 101.6 m in mountain areas, compared to errors of 3.4 m in areas of low relief using SPOT data. DTM have been used to assist in the correction of data in such cases (Haefner & Hugentobler, 1988). One of the methods of error rectification in satellite images is shadow matching.

Data models for mountain environment

The proliferation of GIS is explained by its unique ability to assimilate data from widely divergent sources, to analyze trends over time, and to spatially evaluate potential environmental impact caused by development (ICIMOD, 1995). Therefore GIS should be capable of assimilating the unique factors controlling the pattern of land use in the mountains.

To develop an understanding and appreciation of the optimal locations for settlements and other land uses, it is also essential that the GIS should be able to identify areas affected by the likelihood of natural hazards, whose distribution is influenced by complex interactions between local climates, human activities, soil, bedrock and vegetation characteristics (Hewitt, 1992).

A widely researched GIS application in mountain environments is in landslide hazard zonation (Rengers *et al.*, 1992; van Westen, 1992; 1993; 1994) where either qualitative or quantitative analysis is performed. The analyses have taken various factors of mass movement like geological structure, lithology, hydrological conditions, vegetation, slope angle, and slope aspect into account. A deterministic model of landslide hazard using GIS has become rather popular.

To capture the three-dimensionality complexity of the mountain areas two broad groups of approaches have developed in GIS, one is the DTM approach and the other is the landscape approach. The first involves the use of digital terrain models to provide categorization of zones of elements of a mountain area according to slope, elevation and aspect. The latter uses landscape units, constructed from a synthesis of environmental data, which reflect the character (structure sustainability, and responsiveness) of an area rather than its physical form (height, shape and exposure) alone (Heywood *et al.*, 1994)

The DTM approach: Digital Terrain Models (DTMs) are mathematical models to graphically represent the elevation of the terrain derived from height information (x, y and z values). Information on intermediate height, aspect, slope, shape, radiation incidence, hill shadows, visibility and cut-and-fill estimates can be derived from these models. Data for DTM comes from the following sources *viz.*, ground surveys, topographic maps, satellite imageries, aerial photographs and global positioning systems (GPS). There are two main structuring approaches in DTM; grid-based and triangular irregular network (TIN) method. The former is less computationally intensive than the TIN method. First developed by Peucker (1978), the TIN method is better capable of working on randomly located height data, incorporating break lines, and reduces the data volume. The use of DTMs to help in modeling dynamic mountain ecosystems (Walsh *et al.*, 1994) involve probability mapping for predictable natural hazards using multi-criteria analysis. Weight is attributed to various factors, some of which like slope aspect are derived from DTMs. In satellite images of mountains, land cover should be derived from the total shadow comprises minus the topographic shadow (Paracchini & Folving, 1994), and the integration of DTM with GIS will help in developing highly accurate semi-automatic surface cover mapping from satellite imagery.

The Landscape approach: The landscape approach incorporates behavioural approach of the landscape unit, based on the principles of landscape ecology (Forman & Gordon, 1986). Permanent and dynamic conditions of the land are differentiated. The method of delineating landscape units requires prior knowledge and use of knowledge-based systems. One basic problem associated with this approach is that assessments of stability. Stability is generated by the overlay of landscape units and is not easily interpreted by non-experts in the field. This is posing problems in use of this approach in policy-making.

CONCLUSIONS

Even if total representation of all the complexities of mountain area is not possible, the major and relevant elements characterizing the terrain such as slope, aspect, elevation, macroclimate, and actual accessibility should be taken into consideration in GIS applications for mountain areas if realistic results are desired. The importance of field data and ground truthing should not be underplayed while using advanced techniques like remote sensing or GPS. The user must not be complacent with a 2-dimensional GIS when dealing with mountain areas. The active use of DTM, with overlay and other spatial analyses being carried out on the 3-dimensional model is strongly suggested, and appropriate weightings should be given to different topographic-related factors for the mountain regions. Ideally the mountain scientists require a 'truly 3D GIS' (Stocks & Heywood, 1994), and possibly 'ERDAS Imagine' a step in this direction. Understanding of the role and interrelationship of various factors in ecological setup and land use is essential for spatial analysis. The TIN DTM using statistical techniques (spatial moving averages, kriging and other local interpolation methods) is more advisable for mountain areas unless a very high-resolution grid DTM is used. Draping and 'cut and fill' methods should be correct and visually satisfactory. The landscape approach is more advisable in agro-economic studies otherwise the DTM approach is preferred for spatial analysis of mountain regions. Finally greater resolution and accuracy of data is required in mountain areas due their spatial complexity.

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RABBIT PRODUCTION - A COTTAGE INDUSTRY FOR HIMALAYAN REGION

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Rabbit are reared for their wool, meat, pelts, and as fanciful pets by small-scale producers. In our country, this industry is picking up for wool production in hilly areas of Himachal Pradesh, Uttar Pradesh, Jammu & Kashmir and lately in Sikkim and Arunachal Pradesh and as a broiler industry in areas of temperate and subtropical climate in West Bengal, Assam, Manipur, Andhra Pradesh, Tamil Nadu, Kerala and Karnataka. In many tribal and backward areas rabbits are blazing a new trail in the field of self-employment and picked up as cottage industry by small and marginal farmers.

For wool purpose, a number of Angora strains are available and the best amongst them are French, Russian and German Angora (photograph on cover page). Wool production from Angora rabbit is only 40 tons/year out of which Himachal Pradesh accounts for more than half (24 tons)(Figure 1). Some of the important breeds of meat rabbits are New Zealand White, White Giant, Gray Giant, Soviet Chinchilla *etc.* Segregates of Gray Giant like Black Brown and Dutch type rabbits were also introduced. When well managed, they are very productive, reproducing rapidly and producing good quality meat, wool and fur and can be maintained on kitchen waste, non-toxic weed, locally available leaves, agricultural and industrial by products. They are useful animal for individual farmers, village groups and schools. The rabbits can easily be maintained on high forage, low grain diet that is unsuited for human consumption. Moreover, as compared to other livestock, they require low level of nutrients and energy.



Figure 1. Major rabbit growing areas (marked *) in Himachal Pradesh

The smallest unit that a farmer can start with contain 10 does and two bucks. Rabbits are reared in intensive, semi-intensive and extensive system of management. The correct housing for rabbits is very important, cages must give enough room for the animals to hop about and stretch. They must be protective from predators, well ventilated and easy to keep clean. Rabbit can be maintained either in cages or in floor under strict hygienic conditions. Locally available materials like bamboo, timber, wire mesh, asbestos sheet etc. can be used for preparing correct sized cages. An all wire cage (2'x1.5'x1.5') system supported on metal frame, with automatic feeders and waterers seems to be the most popular in small scale units. The optimum temperature and relative humidity for rabbit rearing is 15-20°C and 60-70% , respectively. It is necessary that light should be provided at least 12-16 hours a day. One precaution for handling of rabbit is to lift the animal by holding the skin behind the ears the scruff, with support by the other hand under the hindquarters

Rabbits like a variety of vegetable material. Tree leaves such as biul, mulberry, bamboo *etc.* are good. Barseen and Lucerne may also be incorporated as per availability. Utilisation of kitchen and garden refuses, weed, leaves *etc.* make meat and wool production in small enterprise possible independent of available farm land. Pregnant and growing rabbits will do better with some grains (concentrates) added to their diet. Drinking water may be provided ad lib in suitable containers.

Breeding management and maintenance of breeding stock play an important role in rabbit farming. The ratio of male and female for breeding is 1:5. Breeding is quite easy but should be used only after fully grown-normally around 8 months old. Choose only healthy, large rabbits which have come from large litters for breeding. Mating is done within buck's cage and if females are ready, mating should take place immediately and may last for 30 seconds to a few minutes. After successful service, the buck usually falls to his side and the doe is removed to her cage. If the doe refuses to mate, it can be presented to another buck very next day. Abdominal palpation 10-14 days after mating is a reliable method of diagnosis of pregnant does. Three weeks later, move the pregnant females into a separate cage with a nest box containing bedding material. She will give birth a month after mating. The nest should be checked as soon as after kindling and dead litter if any, are removed. Litter size generally range from 7-8 for medium/heavy breeds. Weaning of young one is usually done at 6-8 weeks of age.

Rabbit meat is now consumed in small quantities in India. The nutritive value of rabbit meat is very high as compared to other meat. Rabbit meat is easily digestible, the protein content is higher than that of many kinds of meat and the protein value of domestic rabbit rank higher than any other meat used for human consumption besides rich in vitamin B and low in fat and cholesterol contents. Under Indian conditions, broiler production has touched 2.2 kg live weight per animal in the age group of 12 weeks. Further skin of rabbit can be tanned and used in garments, lining, shoes, toys, gloves *etc.* at industrial level. About 50% of the total furskin being produced and utilised by the garment industry world over are from rabbits. As such rabbit raising for furskin production in the fur industry can prove to be a boon to the fur industry.

Angora wool is very fine with a mean diameter of 11mm in comparison to 21.5mm of sheep wool and contain a higher percentage of pure wool and better insulation. The first shearing in kids is normally done after weaning (6 weeks of age) and subsequently every 10-12 weeks. Shearing should be planned in such a way that it does not fall during the extreme cold weather of December and January months and animals should be protected from cold for next 2 weeks to reduce shearing stress. Shearing is usually done manually by a pair of barber's scissors or by electric clippers (photograph on coverpage). Economical shearing is usually achieved when the wool fibre is 6cm long. The wool is graded into various grades for better marketing according to guard hair percentage staple length and presence of matted wool. The best wool will be long, white, clean and unmatted and should be stored loosely in cotton bags or card board boxes.

Angora rabbit wool is a high value commodity, which in respect of fitness and warmth is much superior to sheep wool. Its value per unit weight is 4-50 times that of sheep wool. An adult Angora rabbit of German strain will yield an average 800 gm/annum in 3-4 clips which is four times higher than Marino sheep on body weight basis (Figure 2). After blending with sheep wool, it has been found to improve the handling of wool. Shawls made from Merino and Angora wool have been found to substitute costly Pashmina fibre.

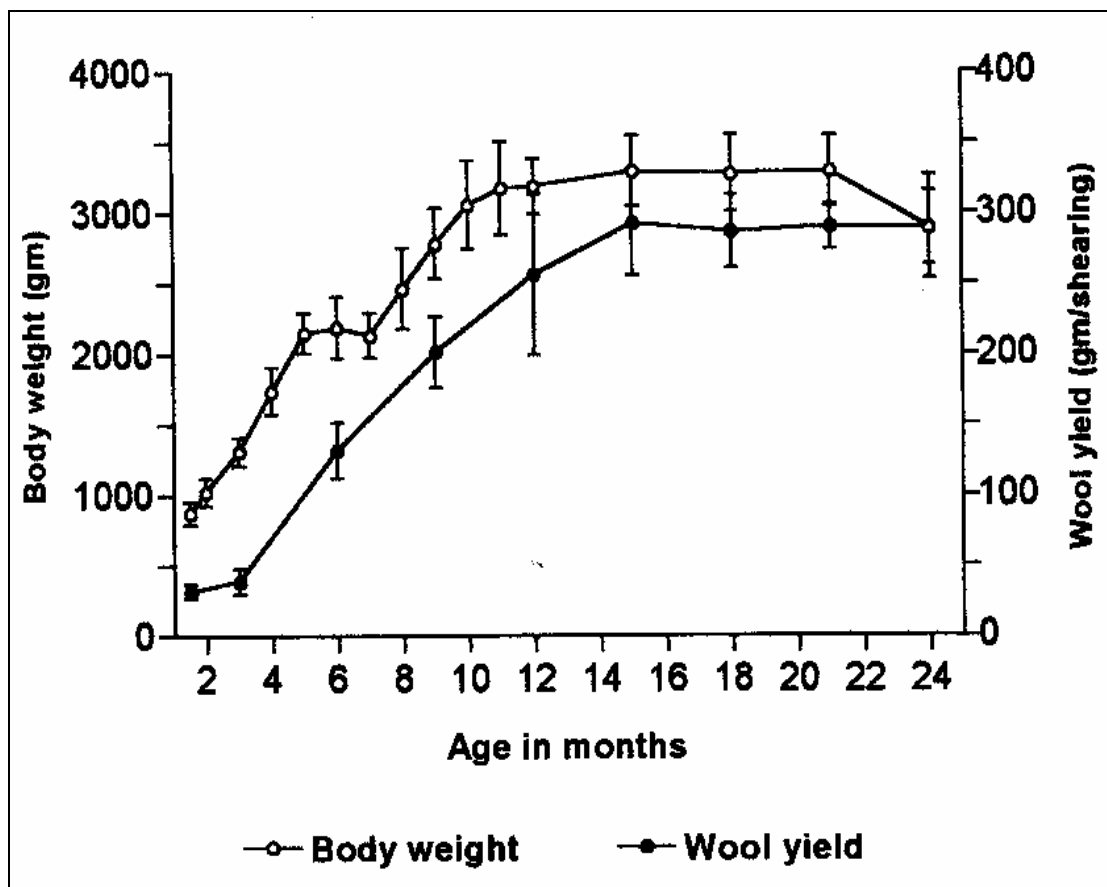


Figure 2. Performance of Angora rabbit in a small farm of Himachal Pradesh

Compared to other farm livestock and poultry, rabbit production is more demanding of technical knowledge and care. Proper sanitation and hygiene is important for successful rabbit production and controlling diseases. The most important diseases of rabbits include coccidiosis, pasteurellosis, enteritis, pneumonia, mange, trichobozoars *etc.*

Some of the measures taken for popularising Angora rabbit farming have been to educate the prospective entrepreneur about various aspects of its husbandry. Presently the state Government impart training in scientific rabbit rearing at various nuclear breeding centres besides supplying the improved seed stock to the needy entrepreneurs in order to boost the various types of literature distributed to apprise the farmers about its economics and salient merits. Government of Himachal Pradesh has announced a support price of Angora wool and introduced market intervention scheme to protect this industry.

Several factors currently limit the economic viability of rabbit production in the region. Rabbit as one of the species of productive livestock has not yet been accepted by animal breeders, scientists and farmers. Due to the less production performance at high temperature, rabbit production is less suitable for hot humid tropics. Since feed is the major cost of production, improvements in feeding and nutrition should aid in making rabbit production profitable. Lack of proper marketing of rabbit meat, fur and wool is also a major constraints faced by the farmers. The susceptibility of the young, is relatively high to diseases originating from the feed of infection. Extension and training activities needs to be strengthened.

SURVEY OF THE DIVERSITY OF LIVING ECONOMIC FLORA AND THEIR CONSERVATION AND DEVELOPMENT IN THE KARBI-ANGLONG DISTRICT OF ASSAM

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The present paper has been undertaken with an attempt to collect and study the plant species of Karbi-Anglong district of Assam which have certain economic potentialities. This study is based on through survey conducted during 1987-1989 for spot collection, identification and economic enumeration of indigenous plants utilized by tribal people of Karbi-Anglong District. In terms of diverse usages of plants recorded during the field trips from different ethnic groups and more particularly of Karbis, Dimasas and Kukis, and assessment has made us regards to vegetable wealth of the district. Of the total 431 plant species, there are as many as 164 species found to be of medicinal plants and 58 species utilized as vegetables. In addition, 44 species of herbaceous plants which have diverse usage by ethnic people but not reported elsewhere have been recorded here for the first time.

The Karbi Anglong and Autonomous Hill District of Assam has been renamed from erstwhile Mikir Hills District in 1976 is one of the two hill districts of Assam, situated in North-East of India, covers an area of 10,332 km². With a total population of 3,79,310 (Census of India, 1971) and 6,55,415 (reported in Assam Tribune dated 28.3.91). Of the total area of 10,332 km² of the district, 2924 km² *i.e.* 28.2% is under forested land less than the Indian percentage nearly 33.

The average altitude of the district is 609.6 m., the highest being at Sinhasen with an altitude of 1357 m. Diphu is the headquarters and Hamren is the second sub-division of the district. Nearly 2/3rd of the district is covered by ridges and rugged hilly terrain. The notable rivers of the district are Dhansiri, Kapili, Jamuna, Kaliani, Borapani, and Doyung. The climate of the district is most unhealthy. It is a malarious region. The district is a rain-shadow area with an average annual rainfall ranging from 780 mm to 1266 mm. The maximum and minimum temperatures are 25.8°C and 17.2°C respectively. Humidity ranges between 50-60%. The district enjoys a moderate rainfall, so it favours the growth of plants of tropical dry deciduous forest with an admixture of semi-evergreen type. The predominant plants of the district are “bamboos”. About 1/5th of the district is occupied by bamboo forest.

Of the total population of the district, 55371 are tribals (Census of India, 1971). Amongst these Karbis are the main inhabitant; Dimasa are the second largest along with the Kukis and Khasis, Mizo, Garo and Chakma. They are predominantly agrarian (Directorate of Information & Public Relation, 1977, Assam, P. 44). Nearly the whole population of the district is dependent on agricultural activities. The chief method of cultivation followed by the hill tribes is Jhumming *i.e.*, Shifting Cultivation.

The methods of farming are unlike the plains, but are similar to that of the hill areas of North-East with little variation in practice. A peculiar feature of the wet cultivation in the most interior places of the district is that “neither plough nor hoe”. A few buffaloes surrounded by people are allowed to trample down the plot until it is puddled and made suitable for transplantation.

The district is economically most backward among the district of Assam, but it abounds in several economically important plants. The vegetation consists of grasses, creepers, bushy evergreen coupled with deciduous trees. The forest resources include food and vegetation plants, timber plants, drug-yielding plants, food adjuncts, beverages and plants of miscellaneous uses. The tribes residing in this hill district are culturally and economically distinct from other tribes of the neighbouring hill districts. The district is inhabited mostly by ethnic groups of people traditionally living close to nature, totally dependent on forest vegetation utilizing many of these plant resources for their food and vegetables, crude method of utilizing plants as dyes, medicines, species, fibres, narcotics and other minor forest products for their daily uses, these plants are mostly of herbaceous ones with a few are found to be shrub by or climbers.

MATERIALS AND METHODS

The present investigation is the outcome of adequate field observations not only of habitats and habits, phenology etc. but also of local uses of plants by undertaking several field trips within the district extending period of collection from March 1987 to December 1989 along with earlier published reports and collectors found deposited particularly in Gauhati University (G.U.) Herbarium and Kanjilal Herbarium, Shillong (Assam). The identification has been made consulting number of Floras, Monographs and revisionary works and later confirmed the identity comprising with authenticated identified herbarium sheets of G.U. Herbarium and Kanjilal Herbarium, Shillong (Assam). Voucher specimens of present collection have been deposited in G.U. Herbarium for future studies.

The investigation of the flora for their various uses was initiated with the involvement of the local people of the areas under survey. The relevant information were recorded for each of the plant species collected. Collections have been made from various locations comprising of both villages situated at foot hills and the forest dwellers. At the time of collection and survey, either the village Head man or old experienced persons were contacted for gathering prior information as regards the use and economic important of different plant species. These two groups of people were persuaded to move along the survey party during the collection of the plant species in the forest and home-stead as well.

Identification

Critical morphological studies have been made of the collected plant specimens. The specimens have been studied by making dissection of a number of flower both live and preserved; analytical drawings of some of the rare and interesting live specimens have been made and drawn out brief description for all for easy identification.

Observation

From the analysis of the collection of the indigenous herbaceous plants, it has been found that the district is one of the richest districts in Assam from the point of view of forest wealth. The forest resources include food and vegetable plants, timber, drug yielding/medicinal plants, food adjuncts, beverages and plants of miscellaneous uses. The species enumerated have been categorized based on the mode of utilization of plants and plant parts and on comparative studies with its published reports indicate that out of 431 species 381 i.e. 88.6% have potentiality for better utilization and 44 species i.e. 10.6% are found no other established reports although these are used locally.

Ethnobotanical information have been recorded from a number of tribes including *Karbi*, *Kuki* and *Dimasa Kachari*. It has been observed that these tribal people have their own unique culture, tradition, medicinal practices, rituals, belief etc. and they make use of various wild plants that too mostly of herbaceous in meeting their requirements.

The food habit of ethnic groups of people of the district has been found to be the same with the other tribes of North-East India. They could not meet their requirements for the whole year from the cultivated crops but found to be dependent on wild plants. So far the food derived from wild plants are concerned, they eat all kinds of wild roots of plants viz, roots *Crotalaria Occulta*, *Ipomoea batatas*; Corms of *Dioscorea alata*, *D. belophylla*, rhizomes of *Curcuma Zedoaria*, *Maranta arundinacea*, *Iris decora*, bulbs & tubers of *Dioscorea bulbifera*, *Colocasia esculenta* and *Alocasia fornicata* etc. Within their reach as well as those crops grown in their fields. Major part of the Karbi found in the hills comes from the jhum fields where they produce varieties of crops including *Oryza sativa* var. *Collina* (hill rice), *Solanum tuberosum* (Potato), *Lagenaria Vulgaris* (Gourd), *Colocasia esculenta* (Arum), *Sesamum indicum* (Sesame), *Brassica campestris* (Mustard), *Saccharum officinarum* (Sugarcane), *Ricinus Communis* (Castor), *Curcuma longa* (Turmeric), *Ipomoea batatas* (Sweet potato), *Manihot esculenta* (Tapioca), *Capsicum* spp. (chillies), *Musa* spp. (Banana) etc. The people accustomed to take vegetables are either in boiled or in roasted form. Mustard oil (*Brassica campestris*) as a cooking medium is rarely used.

Uses of species is also very rare. The fish is almost thoroughly dried in the sun, mixed with salt and little bit of turmeric (*Curcuma longa*) powder to prevent insect damage. The fish so processed is put into bamboo (*Dendrocalamus strictus*) pipe with knot on one side and thus filled up. The mouth of the

bamboo pipe is then carefully sealed with mud to make it air-tight. It can be preserved for the whole year.

For every worship, they sacrifice an animal. Apart from the animal, rice powder and tulsi leaves are also necessary to perform a worship ritual. Karbis believe that water can be purified by dipping tulsi into it. Rice powder is used mainly to make a pattern on the ground or to draw the image of the God that is going to be worshipped. Rice beer has got great social value not only for daily consumption but also for the performance of social and religious rituals in which it is freely drunk by all.

The women are very much fond of wearing large size ornaments which are made of bamboo sticks (*Melocanna bambusoides*). At first a needle-sized fine bamboo stick is inserted into the hole of each ear lobe. The holes are gradually enlarged by inserting bigger sticks as she grows later.

A Karbi woman is tattooed on the face passing from the forehead down to the chin over the nose and the lips. This blue line is called 'duk'. A 'duk' is given to a woman when she is very young by pricking with thorn and then applying a kind of juice extracted from the leaf of a plant called Sibru (*Iodes cirrhosa*).

Different species of bamboo viz, *Bambusa tulda*, *Dendrocalamus hamiltonii*, *D. Sikkimensis*, *D. strictus* and *Melocanna bambusoides* and thatch viz. *Arundinella Khasiana*, *Saccharum spontaneum* etc. are the most common building materials of a typical traditional Karbi house. The house is built on bamboo posts and the floor is raised into a platform usually varying in height from 5-7 ft. or even more. The floor and the walls are made of flattened out bamboo split and the house is roofed with thatch.

The economy of ethnic groups of people is basically agricultural. The methods and quality of their agriculture, however, differs spatially in between hills and plains depending on the nature of topography and the level of development of the society. In the hills, the traditional primitive method of agriculture is still practiced while in the plains there are areas where even modern methods are followed. In some part of the hills, particularly in the interior of Karbi-Anglong, the method and level of economy is still greatly determined and controlled by nature.

From the above findings, it has been observed that the maximum utilization of plant species for various purposes as also annual burning of forest for Jhum cultivation, the species are going to be threatened, the ultimate result would be the extinction of the species from the areas of the study unless a proper strategy for conservation is taken up.

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MAJOR DISEASES OF RICE IN NURSERYBED IN THE LOWER HILLS OF ARUNACHAL PRADESH

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During 1996-97 and 1997-98, survey were conducted in different rice growing areas of West Sing District and its surrounding by the scientist of ICAR Research Complex for NEH Region, Arunachal Pradesh Centre, as the farmers frequently come with problems of rice seedling in nurserybeds. During survey, careful examination of rice nurserybed in situ and laboratory investigations (Comprising of repeated isolation and purification on PDA, microscopic observation and comparison of the fungal structures with laboratory manual (Barnett and Hunt, 1972) revealed that rice seedlings suffered from a number of diseases in nurseries. Though their severity was found to vary from place to place and the types of nurserybed, the disease can not be neglected. During survey, the following nursery diseases of rice seedling were come across in the lower altitudes (660 M m.s.l.) of Arunachal Pradesh.

Seedling Blight (*Sclerotium rolfsii* sacc.)

The disease was commonly recorded in the upland dry nursery bed. The disease caused about 55-60% seedling mortality in nurseries. The disease was more severe during May-June (following intermittent rain and high temperature ranging from 22-27°C) on the seedlings raised in the soil of upland dry nurserybeds which were provided with high quantity of locally available organic manures viz. cowdung, pigmanure etc.

Seedlings in beds are attacked in irregular patches. The affected seedlings are slow in growth. The bases of stem become dark brown, sunken and get rotted. Rotting often results death of seedlings which later dry. Discoloured bases of the stem are found to carry white mycelial strand and rows of white small round sclerotia upto 1-2cm height of stem from the soil level. The sclerotia later turn into light brown colour.

Blast (*Pyricularia grisea* cavara)

The disease was found both in wet and dry seedbed in almost all the rice growing areas of Arunachal Pradesh with varying degree of intensity. There were no observation on complete damage of nursery bed with the disease during survey but higher severity was found to affect seedling health considerably. These infected seedlings were found to cause severe blast later in the transplanted rice field. Blast in nurserybed is characterized by small spindle shaped spots mostly, 1-2 mm, with brown margin and gray centre on leaves.

Brown Spot (*Bipolaris oryzae* Breda de Haan)

Brown spot was also found to occur either singly or in combination with blast both in dry as well as in wet seedbed usually in the month of May-June. The disease in nursery was observed occasionally and severity was supposed to come mainly from seedborne inoculum. Seedling blighting was also observed in patches in some of the surveyed nurserybed.

Presently survey works have highlighted the prevalent nurserybed diseases of rice of Arunachal Pradesh. The diseases need proper management practices, specially in hilly and high rainfall areas to raise healthy seedlings for better crop production.

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PLANT GROWTH, YIELD ATTRIBUTES AND GRAIN YIELD OF SOYABEAN AS AFFECTED BY THE APPLICATION OF INORGANIC AND ORGANIC SOURCES OF NUTRIENTS

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INTRODUCTION

Soyabean has occupied third place in oilseed crops of India, which is a rich source of protein (40-42%) and quality oil (20-22%). It also enriches the soil through symbiosis and leaves about 30-40 kg N (nitrogen) per hectare for succeeding crop (Saxena and Chandel, 1992). With the increasing degradation of the soil through chemical fertilizers, the need to replace them with organic sources which are good for improvement of soil properties, besides supplying nutrients for longer period of time without leaving ill effects on soil, has been realized. Therefore, present study was planned to find out the response of soybean at varying levels of inorganic and organic sources of nutrients alone/combination on growth, yield attributes and grain yield of soybean.

MATERIAL AND METHODS

A field experiment was conducted in the rainy season of 1996-97 and 1997-98 at the crop research centre of the G.B. Pant University of Agriculture & Technology, situated at 29°N, 79° 30'E at an altitude of 244 m amsl. The experimental soil was clay-loam with pH 7.4, org. carbon 0.66%, available P₂O₅ 61.60 kg per hectare and available K₂O 268.80 kg per hectare.

There were 03 replications and 10 treatments viz. :-

- I. T₁ : control (inoculated with *Bradyrhizomium japonicum*)
- II. T₂ : 25 kg N per hectare as urea
- III. T₃ : 50 kg N per hectare as urea
- IV. T₄ : 5 tonne FYM per hectare
- V. T₅ : 1 tonne per hectare
- VI. T₆ : 25 kg N as urea +1 tonne neem cake per hectare
- VII. T₇ : 50 kg N as urea +1 tonne neem cake per hectare
- VIII. T₈ : 25 kg N as urea +5 tonne FYM per hectare
- IX. T₉ : 50 kg N as urea +5 tonne FYM per hectare
- X. T₁₀: recommended doses of NPK (20:60:40) kg per hectare

Soybean variety PK-262 was used with 120-125 days maturity period, inoculated with *Bradyrhizobium japonicum*.

RESULTS AND DISCUSSION

In general, there was increase in plant height, no. of trifoliate per plant and dry matter accumulation per plant of Soybean cv. PK-262 with the increasing rates of N with and without organic sources of nutrients at various stages of growth (*i.e.*, 45 and 60 days after sowing-DAS) (Table 1). The maximum plant height and dry matter accumulation per plant were recorded with 50 kg N as urea + 1 tonne neem cake per hectare at all the stages of growth. The increase in plant height was possibly attributed to internode elongation and other nutrients received by the plants from organic sources. An increase in the plant height with the application of the nitrogen was also reported by Varon *et al.* (1984). Maximum no. of trifoliate per plant was found with 50 kg N as urea + 1 tonne neem cake per hectare at both stages of growth. In the later stages of growth (*i.e.*, 60 DAS) N being an essential component for vegetative growth, produce significant on no. of trifoliate of Soybean combined with organic sources of nutrients (FYM & neem cake). Orellana *et al.* (1990) reported that application of fertilizers at the rate of 20 kg N with 35 kg P₂ O₅ per hectare gave greater no. of leaves and branches in Soybean. The effect of

different inorganic and organic sources of nutrients on dry matter accumulation of Soybean plant was found significant at both growth stages. This was possibly because of supply of N with other nutrients through organic sources particularly neem cake was responsible for better vegetative growth of plant upto reproductive stage during both years. Increase in dry matter production of Soybean with increasing rates of P₂O₅ (0,40 or 80 kg/ha) and FYM (0 and 15 tonne/ha) as also reported by Nimje and Seth (1988).

Table 1. Effect of different treatment on the plant height (cm.), no. of trifoliates per plant and dry matter accumulation per plant (g) of Soybean cv. PK-262 (Pooled data for 1996 and 1997).

Treatments	Plant height (cm.)		No. of trifoliates per plant		Dry matter accumulation per plant (g)	
Days After Sowing	45	60	45	60	45	60
T ₁	45.45	59.53	10.13	17.30	10.93	12.73
T ₂	49.10	62.67	10.67	18.67	12.20	13.50
T ₃	61.00	65.53	13.43	22.57	17.40	18.20
T ₄	51.33	61.67	12.63	20.57	16.13	17.43
T ₅	59.00	64.23	12.77	21.77	16.47	18.67
T ₆	59.43	68.53	16.30	21.77	19.23	21.33
T ₇	64.10	73.10	17.00	34.10	24.83	25.50
T ₈	59.20	66.33	15.87	24.33	18.80	19.87
T ₉	61.53	70.43	16.30	30.10	22.43	23.117
T ₁₀	57.53	64.77	12.30	19.80	14.33	15.17
CD	6.33	5.76	2.70	5.36	2.41	2.73
(P=0.05)						

Pooled analysis on yield attributing characters and grain yield revealed that the various treatments of inorganic and organic sources nutrients significantly affected the yield attributing characters and grain yield except no. of grains per pod. Maximum no. of primary branches of Soybean per plant was recorded with recommended doses of NPK (20:60:40) per hectare which was as par with 50 kg N as urea + 1 tonne neem cake per hectare and 50 kg N as urea + 5 tonne FYM per hectare. Percent increase in no. of primary branches with recommended rates of NPK per hectare over control was 38.80. Likewise maximum no. of pods per plant was recorded with recommended rates of NPK (20:60:40) per hectare which was at par with 50 kg N as urea + 5 tonne FYM per hectare and percent increase of no. of pods per plant with recommended rates of NPK per hectare over control was 113 at harvest. The reproductive growth depends on vegetative growth of plant. More vegetative growth increases Leaf Area Index (LAI) and supply of Photosynthates for the formation of branches and other yield attributes. Jayapaul and Ganesaraja (1990) reported that increase in nitrogen & phosphate rates increased the no. of pods per plant, seeds per pod and 100-seed weight.

Maximum grain yield per hectare was recorded with 25 kg N as urea + 5 tonne FYM per hectare which was at par with 25 kg N as urea +1 tonne neem cake per hectare and recommended rates of NPK (20:60:40) per hectare. Percent increase in grain yield of Soybean with 25 kg N as urea + 5 tonne FYM over control was 127.47 (Table 2). The increase in grain yield of Soybean due to nitrogen application may be because of the fact that nitrogen plays an important role in the synthesis of chlorophyll and amino-acids which are the indispensable ingredients of the process of autotrophization. Nitrogen influenced the grain yield through source – sink relationship resulting in higher production of photosynthates and their increased translocation to reproductive parts. Superior effect of combined use of urea and FYM on grain yield was reported by Tripathi *et al.* (1992). Kumar & Rao (1991) found that seed yield of Soybean increased with increase in nitrogen and phosphates rates from 0 to 40 and 0 to 100 kg per hectare, respectively.

Table 2. Effect of different treatments on the yield attributing characters and grain yield (q/ha) of Soybean cv. PK-262 (Pooled data for 1996 and 1997)

Treatments	No. of primary branches per plant	No. of pods per plant	No. of grains per pod	1000-grain weight (g)	Grain yield (q/ha)
T ₁	6.00	58.40	2.07	127.83	6.89
T ₂	6.77	64.67	2.13	121.15	9.25
T ₃	7.20	83.13	2.00	119.81	8.94
T ₄	6.00	63.47	2.00	120.62	8.00
T ₅	6.33	60.60	1.93	127.47	10.92
T ₆	6.77	81.07	1.93	118.27	15.17
T ₇	7.90	90.87	2.07	126.64	12.33
T ₈	6.80	81.93	2.00	113.95	15.67
T ₉	8.00	112.87	1.87	123.01	12.03
T ₁₀	8.33	124.40	2.07	119.95	13.25
CD	1.29	12.55	NS	7.97	2.72

(P=0.05)

CONCLUSION

The significant interaction for grain yield between combined use of inorganic and organic sources of nutrients and the crop of Soybean revealed that inorganic and organic sources gave higher productivity when applied in combination than that of applied alone. The lowest grain yield was recorded with control which was at par with 25 kg N as urea per hectare, 50 kg N as urea per hectare and 5 tonne FYM per hectare. This shows the importance of simultaneous use of inorganic & organic sources of nutrients. It was concluded that 25 kg N as inorganic source with some organic source (like neem cake & FYM) may be applied for increasing the productivity of Soybean.

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Summary of completed/ongoing projects

USE OF MYCORRHIZAL BIOTECHNOLOGY IN REGENERATION OF CHILGOZA PINE

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Pinus gerardiana is well known for its edible seeds. The seeds locally called and marketed as “Chilgoza” is eaten as dry fruits which is rich in oil, starch and albumenoids. It is one of the most important cash crops of tribal people residing in the Kinnaur district of Himachal Pradesh. Harvesting of almost every mature seed by the right holders for marketing is one of the major reasons for the poor natural regeneration of this pine. Severe biotic interference and lack of regeneration in this pine may result in the extinction of this species. The State Forest Department tried the artificial regeneration of chilgoza pine at many places and performance of seedling is very poor. In all these trials no attention had been paid to the role of mycorrhiza and for using the mycorrhizal symbionts whereas the role of such technologies in establishing conifers under adverse conditions of environment and planting site is well known.

The present project was formulated with specific aim of understanding the role of ectomycorrhizal biotechnology in the artificial regeneration of this important high altitude pine with following specific objectives:

- I. Collection and identification of mycorrhizal associates of *Pinus gerardiana*.
- II. Isolation and screening of different strains.
- III. Production of Mass inocula of different strains.
- IV. Evaluation of the dependency of *P. gerardiana* seedlings of different strains.
- V. Transplantation of inoculated seedlings in different planting sites.

In the present studies three different types of inocula were artificially introduced in *Pinus gerardiana* seedlings grown in polythene bags under glass house conditions after steam sterilization of soil to evaluate them for their mycorrhization capacity. Three inocula including one pure culture of *Rhizopogon rubescens*. Culture isolated from ectomycorrhizal roots and natural soil inoculum from *P. gerardiana* forest. Growth and development was observed after one, two and three years under glass house conditions.

Pure culture inoculum of *Rhizopogon* and pure culture inoculum of root isolate were observed to stimulate the growth and development of seedlings in term of height, biomass, root collar diameter and seedling volume significantly, in comparison to natural soil inoculum and uninoculated control. Among two pure culture inocula *Rhizopogon* culture was observed to form higher ectomycorrhizal root percentage (34%) than percentage of ectomycorrhizal roots formed by roots isolate culture (27%) and natural soil inoculum (29%) after two years of germination. After three years of growth percentage of ectomycorrhizal roots in *Rhizopogon* inoculated seedlings, root isolate and natural soil was 40%, 36% and 32% respectively.

Shoot of seedlings inoculated with *R. rubescens* was observed to have highest concentration of Nitrogen after two years of inoculation. However, difference in concentration of Nitrogen in shoots of all treatments was insignificant after three year of germination. Concentration of Nitrogen in shoots of control seedlings was significantly less than concentration of Nitrogen in shoots of all treatments. Nitrogen content of roots in all treatments after two and three years of inoculations were also significantly higher than concentration of nitrogen in roots of control seedlings. Similarly the concentration of Potassium in roots and shoots of almost all treatments was higher in comparison to concentration of Potassium in root and shoot of control seedlings. Concentration of Phosphorus in root and shoot of root isolated inoculated seedlings was maximum after two years and three years of germination and difference was significantly higher in comparison to concentration of Phosphorus in root and shoot of seedlings inoculated with *R. rubescens*.

Increased percentage of ectomycorrhizal roots through artificial inoculation is directly related to seedling height, seedling biomass and nutrient status. Therefore, it is concluded that, artificial inoculation through selected ectomycorrhizal fungi of *P. gerardiana* should be considered seriously to improve the quality of planting stocks and to stimulate early plant growth. The fast regeneration of Chilgoza pine through mycorrhizal inoculations will play a major role in the economic upliftment of tribal community in Himachal Pradesh and will save this important pine from extinction.

MULTIPLICATION AND CONSERVATION OF SOME ENDANGERED/ THREATENED HIGH ALTITUDE MEDICINAL HERBS

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Studies were conducted on some important medicinal plant species like *Aconitum heterophyllum* Wall. ex Royle (Ranunculaceae), *A. violaceum* Jacq. ex Stapf (Ranunculaceae), *Picrorhiza kurrooa* Royle (Scrophulariaceae), *Meconopsis robusta* HK.f.&T. (Papaveraceae), *Megacarpaea polyandra* Benth. (Brassicaceae), *Rheum emodi* Wall. ex Meissn (Polygonaceae), *Podophyllum hexandrum* Royle (Podophyllaceae), *Angelica glauca* Edgew (Apiceae), *Polygonum rumicifolium* Royle ex Bab.(Polygonaceae) and *Allium stracheyi* Baker (Liliaceae) found in the high altitude regions of Uttarakhand.

The studies revealed that all these species are perennial and their maturity/harvesting time varies from 3-5 years. Seedling growth was observed very slow and during first year of growth only 2-3 leaves are produced. Most of the plants showed rosette vegetative growth and bolting is observed in the mature plants on the onset of reproductive phase. Due to late seed maturation in *A. stracheyi* and *A. violaceum* viable seed production is hampered by severe winter conditions. Seed production potential was observed highest in *Meconopsis robusta* and lowest in *Angelica glauca*.

Among all the species highest germination was observed in *Aconitum heterophyllum* and lowest in *Allium stracheyi*. Although the germination percentage varies greatly in different populations of the same species the timing for the onset of germination and leaf initiation does not vary much in these species. It was observed that seed germination is delayed in soil in comparison to laboratory conditions. Excised seeds favoured germination in *Polygonum rumicifolium*. In *Angelica glauca* it is necessary to store the seeds at low temperature before sowing.

Inhibitory effect of seed coat leachate on seed germination was observed in two *polygonum* species. However, this effect was observed more in case of *P. amplexicaule* as compared to *P. rumicifolium*.

The seedlings of *Polygonum rumicifolium* and *P. amplexicaule* produced from seeds kept under dark showed more starch content in comparison to other treatments. However, the amino acid contents of both the species showed different trend under different treatments. Seedlings of both the species produced from intact seeds showed higher soluble protein in comparison to excised seeds.

Altitudinal adaptation studies conducted in *Polygonum rumicifolium* revealed that total chlorophyll content decreased after one month of transplanting at Tungnath and Srinagar, while the carotenoid content increased at Mastura and Srinagar. Plants transplanted at the selected altitudes experienced decrease in leaf soluble sugar content 30 days after growth in contrast to root system. Similar trend was observed in starch content also. Leaf and root showed different responses in RNA and DNA contents with increasing altitude. A gradual decrease in root DNA content after transplantation at all the elevations is a common feature.

Except *Aconitum heterophyllum*, *Podophyllum hexandrum* and *Allium stracheyi* all other species showed normal dicotyledonous seedling development. The former two species showed pseudo monocotyledonous seedling development while *A. stracheyi* showed the monocotyledonous seedling

development. Highest seedling survival was observed in *Polygonum numicifolium* followed by *Picrorhiza kurrooa* and minimum in *Podophyllum hexandrum*.

Almost all the species have one or more means of vegetative propagation. *Picrorhiza kurrooa* and *Podophyllum hexandrum* showed better response for vegetative propagation in comparison to other species. Tissue culture of young leaves explants of *Angelica glauca* and *Polygonum rumicifolium* showed callusing in different concentrations and combinations of NAA and TDZ.

The overall studies indicated that the above mentioned species though appears to be confined in restricted localities and specific ecological niches in the Himalaya may be cultivated through scientific methods in farmers fields at an appropriate altitude. Till date no large scale farming activity of these species has been taken up by any one in the region. Therefore, the technology for their multiplication and cultivation needs to be demonstrated to the farmers to take up large scale cultivation of these species.

ASSESSMENT OF TOXIC METALS AND NUTRIENTS IN LAKE NAINITAL: BIOMONITORING AND REMEDIATION STUDIES WITH PHYTOPLANKTON AND MACROPHYTES

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Increasing contamination of aquatic resources with a variety of pollutants including toxic metals is not only endangering the aquatic biota, but creating a world wide shortage of recreational and drinking water. This has aroused concern in the mind of public health engineers and biotechnologist to find out economically viable strategies which could help restore such an abused ecosystem. These inland fresh water resources bear the maximum anthropogenic pressure due to large population load and growing needs for economic development. Although the future in the next millennium indeed be determined by availability and quality of water, a little attention has been paid to this problem by the researchers, policymakers and environmental managers. It is befitting to state here that the physicochemical methods available for metal removal require large capital and energy investments. For this reason, phytoremediation is emerging as an effective and eco-friendly alternative ecotechnology for restoration and management of our natural water resource. In this context, the project was undertaken on lake Nainital which serves as a sole source of drinking water in lesser Himalayan region to focus on current status of toxic metal pollution and the role of aquatic macrophytes and phytoplanktons in their biomonitoring and remediation.

The work on the project was carried out on biomonitoring and remediation potential of macrophytes and phytoplanktons for toxic metals in the lake Nainital which is experiencing acute scarcity of potable water due to spurt in anthropogenic activity in the catchment. Besides, receiving a large load of organic inputs through a network of open drains, the improper disposal of wastes, municipal sewage and recreational uses of water have aggravated the level of toxic metals into the lake. Since the lake serves as major source of usable water to local inhabitants, the hazardous impact of toxic metals on the human health can not be ruled out. Therefore, the chief objective of the project was to find out suitable remedial measures and proper waste disposal system in lake Nainital. This is relevant with reference to great lakes water quality agreement (IJC, 1992) to check the discharge and elimination toxic pollutants.

For the accomplishment of the goal, sampling strategy was decided by selecting eight randomly located sampling sites in the lake depending upon the type of pollutant inlet and in different quarters of the year to account for seasonal fluctuations in different components of the lake. A view of eutrophicated lake and sites from I to VIII has been shown in figures 1 and 2. All the determinations were performed using standard procedures. A view of the main domestic drainage falling into lake Nainital, growing stands of macrophyte *P. amphibium*, water roots of *Salix*, Blooms of *Microcystis*, the recreational and natural clematis adding pollution to lake.

Results of the study carried out during August, 1996 to June 1999 showed that the physicochemical properties of lake water varied from one quarter to other during the year. Although there was not much variation with respect to other parameters, the level of NO_3^- increased during winter season while the values of electrical conductivity increased during rainy season of the year. There was not significant variation in the other parameter at different sampling stations. However, the value of COD was recorded much higher at sites SI and SII in all the sampling years. Over all the physicochemical properties of lake ranged as temperature, 8.7-22.6°C, pH 7.7-8.4, electrical conductivity, 0.26-1.13 dSm^{-1} . TDS- 31.0-357, D.O.-3.6-8.25, COD- 10.0-72.87, BOD- 5.0-18.18; NO_3^- -0.55-1.6, NH_4^+ - 0.025-0.329 $\mu\text{g cm}^{-3}$.

Results of water analysis revealed that the lake water was contaminated with toxic metals like, Cu, Mn, Fe, Pb, Ni and Zn, however, the concentration of some of these like Pb, Fe and Ni were higher than the permissible limits recommended by WHO. The concentration of these metals ranged through out the course of entire investigation as Cu- 0.05-0.25; Fe- 0.61-0.71; Mn- 0.039-0.27; Ni-0.21-0.345; Pb, 0.155-1.41 and Zn, 0.08-0.225 $\mu\text{g cm}^{-3}$.

NANISAR MINI MICRO WATERSHED MANAGEMENT PROJECT

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The pattern of land ownership and land laws enacted from time to time have largely determined the land use and land management in India. In Central Himalayas the land holdings are fragmented. An average land of 20 nalis is divided into 45 to 50 small terraced plots, scattered all over. Fragmented land holding is one of the cause of people following the traditional unproductive pattern of agriculture and due to low productivity the rate of male migration is increasing rapidly.

Land consolidation is an issue which needs rethinking on the part of the people, although it is a state issue. It could be given concrete form by mutual understanding, because without land consolidation it is very difficult for the farmer to work effectively on his fields. What we can do is sit together and enact a specific plan for consolidation of fragmented land. Although a lot of problems may come on the way, for example some people may find the land too far from these houses or the land allotted to him may be less fertile and far from the water source, but anyhow we have to solve this problem for better results. Another thing we can do is to plan a common crop pattern for all, according to the soil fertility, slope of the land and soil pattern. Common crops can be grown in an area where the fertility of soil, slope and humus content are same. For this we'll have to form a community organization, in which women and youth groups will be included, particularly women because it is the women who looks after most of the house hold and agriculture work as men are generally residing in cities to earn money. It is the women who does maximum work that's why their participation is a must. Youth's participation is also necessary, as hard physical work is difficult for women. The people should be informed about how to manage their resources and how to take advantage of these resources for their own welfare. We will have to generate awareness among women and youth to work for their upliftment by joining hands.

Selected Abstracts

Compiled by D.S. Negi

G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, India

Agrawal, D.K. and Rikhari, H.C. 1998. **Mountain risk engineering : Low cost biological and physical measures for control of small hill slope instabilities.** *Research for Mountain Development*: 119-144. G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [BIO-ENGINEERING; LANDSLIDE; LIVESTOCK; MOUNTAIN RISK ENGINEERING]

This study has been carried out in two villages (*i.e.*, Joshiyana and Khoont located at 1300 m amsl) Kumaun Himalaya in order to implement various practices and objectives of Mountain Risk Engineering (MRE), an eco-friendly mountain area developmental programme. The basic theme of MRE is to stabilise small hill slope instabilities through low cost biological and physical measures, involving basic skills of various disciplines. One of the major achievements of this study is successful peoples' participation in the various activities. The entire exercise helped in achieving the other objective of MRE. It also provided insight to appropriate approaches, to be adopted for taking up location specific problems of small hill slope instabilities. The rate analysis norms developed and experienced could be of great help in similar future activities. Another important outcome of the work is to identify suitable bio-engineering treatments for the region along with suitable plants species and their functions in slope stabilisation.

Dhar, U.; Rawal, R.S.; Samant, S.S.; Bhatt, I.D. and Mehta, D.S. 1998. **People's participation in Himalayan biodiversity conservation - learning through experience.** *Research for Mountain Development*: 375-386. G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [AUDIO-VISUAL; BIODIVERSITY; CONSERVATION]

Realizing the potentials of people's creativity and energies for furthering the cause of conservation in the Himalaya, core group Conservation of Biological Diversity initiated an activity "People's Participation in Himalayan Biodiversity Conservation" in 1995. Envisaged to develop a precisely defined and practically feasible participatory programme for conservation of Himalayan Biodiversity, the programme features were clearly defined under three stages *viz.*, planning, process and product. Through this exercise implementation and outcome of programme were evaluated. Considering the remoteness of the area, richness of biodiversity elements, diversity in resource utilization patterns and traditional conservation practices, district Pithoragarh in Kumaun was identified as target area. Following target groups were recognized based on their specific work area, choices and skill (i) Resource group, (ii) Management group, (iii) Workforce group. With the identification of target area and groups Phase I of the programme was launched in the form of Training Workshop and Discussion Meeting. Three training workshop and one preparatory meeting were organised in this phase. As a result, training of over 240 participants, initiation of conservation models; development of print material, and data generation based on the feedback of participants was achieved. General agreement of target groups with programme objectives and their willingness to participate in future activities suggest overall success of the programme. However, critical assessment of the activities and analysis of the feed back ensured further improvement in programme features. For example, educational institutions (Management and Workforce groups) were recognised as managers and promoters capable of addressing the problems of resource group indirectly. Keeping this in mind further expansion of programme is envisaged.

Dhyani, P.P. 1998. **Badrivan programme at Badrinath dham : An innovative model for restoration of degraded lands and biodiversity conservation.** *Research for Mountain Development*: 387-399. G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [BIODIVERSITY; BROAD-LEAVED TREE; CONSERVATION; DEGRADED LANDS; SEEDLING]

An innovative programme under the name of "Badrivan (ancient sacred forest of Badrinath) Restoration Programme" was launched at Badrinath, Chamoli Garhwal (U.P.) with effect from 1993. The methodology developed and tested and the demonstration model established at Garhwal Scouts Camp and Parmarthalok have successfully inspired the pilgrims and local people from all walks of life to restore the degraded lands in and around Badrinath dham, the major Hindu pilgrimage shrine in the Indian Central

Himalaya. The successful tree planting by organizing Ritual Distribution of Tree Seedlings and Plantation Ceremonies (RDTSPCs) and Plant Distribution Ceremonies (PDCs) at Badrinath for revival of Badrivan also demonstrates what kind of cultural approaches for reforestation of degraded lands can work, and as to how science and religion can work together for the benefit of the environment and conservation and preservation of the spiritual and cultural values. This R & D effort provides an inspiring model for reforestation of degraded lands and biodiversity conservation and needs replication not only in the Himalayas but also in the other parts of the world where sacred sites and pilgrimages are important and the environment has been severely threatened.

Farooque, N.A. and Rao, K.S. 1998. Changing values in traditional societies and ecological implications. *Himavikas Occasional Publication*, 11: 233-238. G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [ECOSYSTEM; INFRASTRUCTURE FACILITIES; LIFESTYLES; RURAL ECONOMY]

The close dependence of traditional communities on local ecosystems for their survival share a common threat from the dominant world culture characterized by high level of consumption and over exploitation. The Monpas, a pastoralist traditional community in eastern Himalaya depended on the natural grazing lands and forest for centuries and are now caught in the web of development which is leading to drastic changes in their society and ecology of the area. In the process of development the road network, infrastructural facilities, education communication and market economy have though improved, the quality of life, failed to environmentally compatible lifestyles. The change in values, ethics and code of social and cultural behaviour are visible as competition, personal growth, wealth accumulation and self before society. This is extreme from the traditional society values which professed community before self and equitable sharing of available resources. The fast pace of such changes in society in north eastern India are major concern for planners and administrators as the resource consumption rates by the changing society for exceeds the carrying capacity limits. The present paper examines the concepts of changing values in traditional societies and their implications for the ecology of the region with special reference to Monpas of Arunachal Pradesh.

Farooque, N.A. and Rao, K.S. 1998. Transhumance: An adaptation for survival and strategy for conservation of natural resources. *Research for Mountain Development*: 145-163. G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [CONSERVATION; ECOLOGICAL CONDITIONS; LIVESTOCK MANAGEMENT; MEDICINAL PLANT; NATURAL RESOURCE]

Transhumant pastoral production in the high altitudes of Indian Himalaya is oriented towards guaranteeing a subsistence livelihood by efforts to attain food production and to reduce environmental risk. Production strategies involve the simultaneous use of several ecological zones each year to utilise the available resources in a judicious manner. This way of human adaptation has led to the conservation and utilization of indigenous cattle and livestock for centuries. The self-contained existence of transhumant societies of Indian central and eastern Himalaya which remained largely undisturbed for centuries have under gone drastic change over the past decade, resulting in the transformation of agricultural and pastoral systems. Cultural cohesiveness and social solidarity had helped the community to continue as transhumant pastoralists, but now they are trapped in the net of modern development which has sown the seeds of their disintegration. The transhumant techniques and system of optimal utilization of available resource had evolved with their adaptation to this extreme conditions of high altitude Himalaya. This study also highlights the various conservation measures ingrained in the traditional systems, and how these people have domesticated and preserved a number of plant and animal species either through their domestication, or utilization for a number of purposes. But now, the construction of roads in the region and introduction of communication and other developmental infrastructures threatens the traditional way of life, and their immediate environment.

Farooque, N.A. 1998. Development and the eradication of traditional resource use practice in the Central Himalayan transhumant pastoral society. *International Journal of Sustainable Development and World Ecology*, 5: 43-50. G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal,

Almora 263 643, U.P., India. [HIMALAYA; RESOURCE USE; SUSTAINABLE DEVELOPMENT; TRANSHUMANT]

The intricate and complex relationships between transhumant pastoralists, livestock and environment at the high altitudes of Indian Central Himalaya has started to break down at an alarming rate. Some of the important factors attributed to this are depletion of grazing resources, commercialization of the rural ecology, and integration of these communities with the mainstream of development through education and employment. Traditionally these livestock were assigned different roles in society depending upon their economic benefit and utility. The roles which once depended upon attitude to various risks, such as environmental, social and economic, have lost their significance due to changing of the production process. This paper gives an overview of the various types of roles the livestock played in the transhumant society, and how they are being replaced by the developmental process in the region, and whether the changes are sustainable for such remote regions in a developing country.

Farooque, N.A. 1998. Diversity: An important issue of sustainability in Indian context. *Man in India*, 78(3&4): 341-347. G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [DIVERSITY; ECOSYSTEM; MIXED ECONOMY; SOCIO-CULTURAL]

The growing global movement and concern on the biodiversity loss over the past decade, has drawn the attention in trying to understand diversity in its various forms. Combining the insights from the disciplines of ecology, economics and anthropology, this paper tries to understand the role of human diversity and their diversified activities in the sustainability and continuity of a society, and the different types of impacts and pressure it exerts in the various policies of the country including foreign policy. Regarding the biological conservation, this implies the maintenance of sufficient biodiversity to assure the resilience of ecosystems delivering ecological services of fundamental value to human societies (Perrings *et al.*, 1992). Human diversity's commonly understood as a product of biophysical conditions, where an intimate relationship between culture and its environment exists. Though anthropologists have interpreted human diversity differently, but all have a common flow of argument regarding the linkages between culture and its environment. Culture as a design for society's continuity stipulates its environment by its mode of production and material requirements of its social structure (Sahlins, 1969). Cultural change takes place to facilitate adaptation (Steward, 1955). Thus, the hypothesis of the adaptation of human populations to specific environmental conditions are by means of its socio-cultural institutions (Anderson, 1973). Hence, human diversity is a direct product of biophysical diversity, and its stability and sustainability lie in its continuity.

Farooque, N.A. 1999. Culture diversity : The key to Himalayan sustainability (A study of Indian Central Himalaya). *Man in India*, 79(1&2): 53-67. G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [CENTRAL HIMALAYA; CULTURAL DIVERSITY; FOOD CROP; SOCIO-ECONOMIC]

The Indian Central Himalaya has been receiving large amounts of development assistance, largely as a response to create infrastructural facilities for enhancing its production and better living. This paper suggests to understand how the present developmental initiative have marginalised the Himalayan diversities, and has encouraged a narrowing of the economic, cultural and ecological characteristics of the region. Thus, has brought the society at the cross roads of unsustainability.

Farooque, N.A. and Nautiyal, Annpurna 1999. Traditional knowledge and practices of Bhotiya pastoralists of Kumaon Himalaya: the need for value addition. *Int. J. Sustain. Dev. World Ecol.*, 6: 60-67. G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [CATTLE BREEDING; CENTRAL HIMALAYA; HIGH HILLS; MEDICINAL PLANTS; PRACTICES; TRADITIONAL KNOWLEDGE; VALUE ADDITION]

Little is known about traditional knowledge and practices developed by the transhumant society on available plants, animal resources, medicinal herbs and other technologies of high altitude Himalaya, where resources are scarce. Moreover, these traditional specialization of the indigenous people known as 'Bhotiyas' are breaking down because of lack of income generation and value addition. The impact of modernization and development has relegated the traditional systems of medicine, handicraft and cattle breeding further

behind. The institutional attitude towards such knowledge systems has also been quite discouraging. This paper tries to document the traditional knowledge of some important herbs in their society, traditional cattle breeding achievements, and the traditional handicrafts, and suggests the immediate need for value addition in these sectors in order to save them from extinction and to add to the income of the people.

Jamir, S.; Changkija, S.; Rao, K.S. and Sundriyal, R.C. 1998. Improving jhum system performance with multipurpose hedgerow introduction in North East India. *Research for Mountain Development*: 83-96. G.B. Pant Institute of Himalayan Environment and Development, North East Unit, Vivek Vihar, Itanagar 791 113, Arunachal Pradesh; Department of Botany, School of Agricultural Sciences, Nagaland University, Medziphema, Nagaland; G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [AGRO-FORESTRY; FODDER; NITROGEN FIXING; SANDY-LOAM]

Jhum is a predominant land-use and an economic activity for majority of population in the north-east region which aimed at maintaining high crop diversity, achieving food security through utilising locally available organic resource for sustained yields and cooperation/social integration at a local scale. Shorting to jhum cycle during recent years has put tremendous pressure on resources and thus effecting productivity of land caused by land degradation, increased levels of soil erosion, hydrological imbalance, forest degradation leading to low yield and insecurity in food source. Slopping agricultural land technology, which is based on growing nitrogen fixing and fast growing hedgerow species and aims at soil conservation with fertility management, provides opportunities for optimal land-use of slopping land by adequately conserving soil and water, enriches soil, stabilise slopes and allows cultivation without terracing. The present study was focused on the jhum fields of Changki, Nagaland which envisaged to increased production of food grains, vegetables, fruits, cash crops and fodder while maintaining the traditional status of the land. Four models, all incorporating N₂-fixing hedgerows species, consisting of traditional farming (model-I), traditional farming + livestock including fisheries (model-II), agro-forestry (model-III), and horticulture crop (model-IV) were developed. Through the project existed for three years only, it showed a trend of improvement in soil and nutrient conservation, and socio-economics, and it is expected that in near future the approach and concept of the models developed will have wider application to those interested in the sustainable development of the upland areas in whole of the north-eastern region. It is suggested that through there are positive indication of adopting this technology, it should be tested more in different areas and diversified conditions with local modification, before taken for large scale replication.

Joshi, S.C. and Palni, L.M.S. 1998. Clonal variation in temperature response of photosynthesis in tea. *Plant Science*, 137: 225-232. G.B. Pant Institute of Himalayan Environment and Development, Garhwal Unit, P. Box-92, Upper Bhaktiyana, Srinagar Garhwal 246 174, U.P., India; G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [CLONAL VARIATION; PHOTOSYNTHESIS; TEA CLONES; TEMPERATURE RESPONSE]

The effect of temperature on the photosynthetic characteristics of six tea clones (*viz.*, 6017, B/5/63, B/6/61, B/6/62, CCS-26 and T-78), originally from different agro-climatic zones in India, was studied to determine the clonal variation in photosynthesis, if any. The results clearly indicated significant clonal difference in relation to temperature. Of the six clones, B/5/63 and B/6/61 were found to be relatively thermocolerant. Both stomatal and mesophyll components seemed to be responsible for the differences in temperature dependence of photosynthesis, however, their magnitude varied with the tea clones. Differences in water use efficiency were also observed between clones. However, differences became less pronounced at the higher temperature. Clone B/5/63 showed higher water use efficiency and lower values for stomatal conductance and transpiration. Thus this clone may be suitable for relatively dry and exposed sites. A 2-10-fold increase in dark respiration with increase in temperature was also observed. However, higher increase was associated with clones having higher photosynthetic rates, indicating an association between photosynthetic and respiratory rates. The results provide a valuable indication regarding clonal variation in temperature responses of photosynthesis and may be used to offer useful suggestions to tea growers in the initial selection of tea clones.

Kant, Vijay and Vashist, D.P. 1998. **Effect of GA₃ and storage on germination of *Nardostachys jatamansi* seeds.** *Journal of Hill Research*, 11(2): 202-206. Plant Physiology Laboratory, Department of Botany, H.N.B. Garhwal University, Srinagar (Garhwal) 246 174, U.P.; Division of Environmental Physiology and Biotechnology, G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [AROMATIC PLANTS; GARHWAL HIMALAYA; GERMINATION; POLYTHENE]

Viability, germination, and storage as affected presowing treatments was studied of *Nardostachys jatamansi* DC, an endangered medicinal and aromatic plant (family Valerianaceae). Seeds sowing germination significantly better in freshly collected seeds, cold stored seeds and presowing treated seeds. Germinability of seeds were improved up to 15% by GA₃ treatments.

Kumar, Anil; Sood, A.; Palni, L.M.S. and Gupta, A.K. 1999. ***In vitro* propagation of *Gladiolus hybridus* Hort.: Synergistic effect of heat shock and sucrose on morphogenesis.** *Plant Cell, Tissue and Organ Culture*, 57: 105-112. G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India; Division of Biotechnology, Institute of Himalayan Bioresource Technology, Palampur 176 061, H.P., India. [CARBOHYDRATES; GLADIOLUS HYBRIDUS; HEAT SHOCK; MICROPROPAGATION; MORPHOGENESIS; PLANT GROWTH REGULATORS AND ROOTING]

Three cultivars (cvs.) of *Gladiolus hybridus* Hort., namely 'Her Majesty', 'Aldebaran' and 'Bright Eye' were successfully micropropagated. The cultures were established using intact cormels or segments of cormels and inflorescence axes on Murashige and Skoog (1962;MS) medium. The response depended on media supplements; both callus formation or direct induction of shoot buds was observed. Shoot differentiation from callus could be obtained on MS medium containing 1.0 μM BA (6-benzyladenine) and 10.0 μM NAA (α-naphthalene acetic acid) in all three cultivars. The same could be achieved by giving a heat shock (HS;50°C, 1h) to callus cultures (in case of 'Her Majesty' and 'Aldebaran' only) maintained on the basal medium. In these two cultivars, high sucrose concentration (0.232, 0.290 or 0.348 M) also favoured growth and proliferation of shoot cultures on a plant growth regulator-free medium at 20°C in comparison to the cultures kept at 25°C. On the other hand, shoot cultures maintained on the basal medium at 25°C containing normal (0.058 M, i.e., 2.0%, w/v) sucrose concentration responded similar to those maintained at 20°C on a high sucrose medium; reduced response was observed on normal sucrose containing medium at 20°C. Heat shock enhanced shoot proliferation in the cultures maintained on basal medium, but induced prolific rooting in shoot cultures, within 5 days of HS, on high sucrose (optimum 0.232 M) medium. While the number of roots increased at higher sucrose concentrations in the medium in case of cvs. 'Her Majesty' and 'Aldebaran', the same was found to be independent of sucrose concentration in cv. 'Bright Eye'. Generally the rooted plants produced on high sucrose (0.232 M) medium in comparison to medium with normal sucrose concentration showed better survival (ca. 90% as against 40%) in the soil.

Maikhuri, R.K.; Rao, K.S. and Semwal, R.L. 1998. **Biosprospecting for economic development in the rural Himalaya - A case study.** *Research for Mountain Development*: 235-252. G.B. Pant Institute of Himalayan Environment and Development, Garhwal Unit, P. Box-92, Upper Bhaktiyana, Srinagar Garhwal 246 174, U.P., India; G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [AGROECOSYSTEM; ECONOMIC DEVELOPMENT; FRUIT-YIELDING; SOCIO-ECONOMIC]

Garhwal Himalaya is an important source of wild fruit species. Many of these fruit varieties are eaten raw and used locally, but not yet been considered as a source of alternative food products. However, a large quantity of these fruits are wasted whilst many of them are rich source of protein, minerals and medicine. With this in view, about 13 potentially exploitable species of wild fruits and one semi-domesticated species having high potential for exploitation were selected for study; six of them (*Aegle marmelos*, *Berberis asiatica*, *Hippophae rhamnoides*, *Myrica nagi*, *Rubus ellipticus* and *Prunus armeniaca*) were examined in detail for their economic potential. An attempt was made to utilize these wild fruits as a source of income, particularly for poor rural inhabitants and unemployed youths of the region by making a variety value added edible products such as jam, jelly, juice, squash, sauce, etc. The enterprise was demonstrated successfully to the people to encourage them to adopt it in the form of a small village-level cottage industry. It is evident that

most of the items prepared from a variety of wild fruits have a promising economic potential. The total output, as well as the net return, is very high for all the food items prepared. This is to be expected, because all these plants grow abundantly in the wild, where no further input of any kind is required, except that of collecting the fruits. It is interesting to mention here that recently some of the local NGO's and local people of the region have brought Ames (*Hippophae*) and other wild fruit products into the local market.

Maikhuri, R.K.; Rao, K.S.; Palni, L.M.S. and Rai, R.K. 1998. **Biosphere reserve programme in India.** *Himavikas Occasional Publication*, 12: 1-7. G.B. Pant Institute of Himalayan Environment and Development, Garhwal Unit, P. Box No-92, Srinagar-Garhwal, U.P. 246 174; G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P.; C.S. Division, Ministry of Environment and Forests, Paryavaran Bhavan, CGO Complex, Lodhi Road, New Delhi 110 003, India. [BIODIVERSITY; BIOSPHERE RESERVE; SUSTAINABLE DEVELOPMENT]

Biosphere reserves should preserve and generate natural and cultural values, through management that is scientifically correct, culturally creative and operationally sustainable. The world network of biosphere reserves, as implemented through the Seville Strategy, is thus an integrating tool which can help to create greater solidarity among peoples and nations of the world: UNESCO, 1995.

Maikhuri, R.K.; Semwal, R.L.; Vishvakarma, S.C.R. and Rao, K.S. 1998. **Low cost water harvesting technology for life saving irrigation for crops and afforestation programmes in Himalaya.** *Research for Mountain Development*: 49-64. G.B. Pant Institute of Himalayan Environment and Development, Garhwal Unit, P. Box No-92, Srinagar-Garhwal, U.P. 246 174; G.B. Pant Institute of Himalayan Environment and Development, Himachal Unit, Shamsi, Kullu; G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P. [CONSERVATION; ECONOMIC DEVELOPMENT; FOOD PRODUCTION; RESOURCE MANAGEMENT; WATER HARVESTING]

Water is a unique substance and it is essential for human, animal as well as plant survival. Agriculture requires vast quantities of water. In fact water is a vital source of energy and provides an important means of irrigation efficiency in food production. Neither the supply of water nor its distribution is uniform throughout the surface of the earth. This has resulted in an apparent imbalance between demand and supply of this vital natural resource. Some regions are blessed with a fairly uniform and more than adequate supply for human and agricultural needs, but many other have a greater need for water than the present supplies. The social and economic growth and development of any region depends on the availability of water. Agriculture, which provides livelihood for all is the main source of economic development and entirely depends on the water. Keeping in view the acute shortage of water, a technique of water harvest and conservation has been proposed particularly in areas or villages which are situated between 400-1600 m elevation with an aim to make full use of available water by collecting it into the water tank of different sizes depending upon the catchment of the area and using it for production purposes.

Nandi, S.K.; Rikhari, H.C.; Sharma, S.; Nadeem, M. and Palni, L.M.S. 1998. **Himalayan Yew: Conservation strategies.** *Research for Mountain Development*: 341-356. G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [CANOPY; CONSERVATION STRATEGIES; SEED GERMINATION; TAXUS BACCATA]

Taxus baccata L. subsp. *wallichiana* (Zucc.) Pilger has come into prominence in recent times due to its uncontrolled harvesting from the Himalayan wilds for the extraction of anticancer drug taxol (paclitaxel). It is a very slow growing tree with poor regeneration, and the extent of canopy damage is likely to have serious consequences on biomass yield, plant survival and natural regeneration by affecting 'seed' output. A study in the Jageshwar area of the Central Himalaya describes the site characteristics, canopy removal and regeneration of this species in human disturbed and undisturbed sites. It has been found to grow between 1770 and 1920 m amsl on all aspects in moist and shady places, except the drier south aspect. The number of trees, saplings and seedlings varied from one site to another. Regeneration of the species was found to be better in undisturbed sites with moist and shady microsites in comparison to disturbed sites. Of the total canopy volume, 57.4% was found to have been removed from the study area (9.54 ha; representing about 8% of the total area under *T. baccata* habitat). It was also considered relevant to develop a simple and efficient

clonal(vegetative) multiplication protocol for mass propagation. Thus, the effect of various chemicals and seasonal effect, if any, on rooting ability of stem cutting was studied. In general, lower concentration (0.25 µM) of both IBA or NAA (both auxins), and Bavistin (0.05%, w/v; a systemic fungicide) were effective in inducing adventitious rooting. Among the phenolics, 40% rooting was achieved with phloroglucinol only, while coumarin and gentisic acid were ineffective. The seasonal effect of chemical induction of rooting stem cutting was in the order of monsoon > winter > autumn. The reported poor seed germination has been enhanced. Survival of vegetatively propagated plants following transfer in their natural habitat was about 36% over a period of 3 years. Efforts undertaken for its conservation and some future strategies have also been discussed.

Nautiyal, S.; Maikhuri, R.K.; Semwal, R.L. and Rao, K.S. 1998. Conservation through cultivation: A case study of medicinal plants in buffer zone villages of NDBR. *Research for Mountain Development*: 357-374. G.B. Pant Institute of Himalayan Environment and Development, Garhwal Unit, P. Box No-92, Srinagar-Garhwal, U.P. 246 174; G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P. [AGRO-CLIMATIC CONDITION; BIOSPHERE RESERVE; BUFFER ZONE; MEDICINAL PLANT]

Conservation oriented natural resource management options are of significance for effective management of biosphere reserves where reserve people conflicts are the major attention of management plans. The local villagers in buffer zone of Nanda Devi Biosphere Reserve practice medicinal plant cultivation and this is in tune with the conservation oriented land uses. The efficacy of resource use and economic returns indicate how such low-volume, high value crops have potential for economic betterment of people while helping the cause of conservation in any protected area.

Negi, G.C.S.; Joshi, V. and Kumar, K. 1998. Spring sanctuary development to meet household water demand in the mountains: A call for action. *Research for Mountain Development*: 25-48. G.B. Pant Institute of Himalayan Environment and Development, Garhwal Unit, Srinagar-Garhwal; G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [HOUSEHOLD; LESSER HIMALAYA; SOCIO-ECONOMIC; SPRING SANCTUARY DEVELOPMENT; WATER RESOURCE]

In the Lesser Himalayan region fragile watersheds harbour a wealth of water sources which are utilized by the inhabitants for drinking and other household consumption. Unfortunately, in the recent decades water yield of these sources has declined drastically and some of them have dried up. Many natural and human induced reasons, such as, erratic rainfall, deforestation, forest fires, roads, building constructing, mining etc., in the water recharge zones have been attributed to this phenomenon. Mismanagement of the vast water resources is also a major reason behind this problem. In the present circumstances of decline in water sources and uncertainties associated with the water supply of Government schemes, the "spring sanctuary development" approach carry a potential to meet the household water need of the people and may gather public participation at a watershed scale. The present article gives an account of household water consumption, spring recharge zones, spring discharge and "spring sanctuary development" studies carried out over five years in Dugar Gad watershed of Garhwal Himalaya. Five springs were measured for weekly discharge, and recharge zone of a nearly-extinct spring was treated with engineering and vegetative measures. In the seasonal springs, the discharge was found more dependent on rainfall; and in the perennial springs, discharge was less dependent on rainfall. Spring recharge zones with saucer shape, south-east aspect, abandoned terraces, bushland, a few mature trees and low incidence of grazing were found conducive for spring water yield. Geologically these springs were identified as colluvial-related and fracture/joint-related, respectively. Increase in the discharge of the nearly-extinct spring from 595 l/d in June 1995 to 2170 l/d in June 1998 was recorded, which convince about the replicability of this technology in similar watersheds of the mountains. It was found that water availability and demand vary from one village to another, making one village water deficit and the neighbouring village a water surplus one. Pooling the discharge of all the springs and fixing a water distribution schedule has a potential to meet the normal water demand even in summer. Thus dispelling the false notion of water crisis in the water resource rich Himalayan watersheds. A management plan for household water consumption has been presented for Dugar Gad watershed.

Palni, L.M.S.; Bag, N.; Nadeem, M.; Tamta, S.; Vyas, P.; Bisht, M.S.; Purohit, V.K.; Kumar, A.; Nandi, S.K.; Pandey, A. and Purohit, A.N. 1998. **Micropropagation: Conservation through tissue culture of selected Himalayan plants.** *Research for Mountain Development*: 431-452. G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India; High Altitude Plant Physiology Research Centre, H.N.B. Garhwal University, Srinagar, Garhwal 246 174, U.P., India. [MICROCLIMATIC CONDITION; MICROPROPAGATION; *PODOPHYLLUM HEXANDRUM*; TISSUE CULTURE]

The uncontrolled exploitation of plant species of the Indian Himalayan region has not only reduced the forest cover but also several important highly valued medicinal plants. Plants are directly linked to the life and economy of the people living in the hills. In recent times the use of modern methods of tissue culture has helped to supplement the conventional means of propagation and hence the micropropagation technology with the potential of rapid and mass multiplication offers realistic prospects in various developmental programmes. In view of the importance, micropropagation and somatic embryogenesis have been applied successfully in selected species, namely *Camellia sinensis* (tea, a plantation crop of major commercial importance), *Dendrocalamus hamiltonii* ('maggar' bamboo, a multiutility plant), *Quercus semecarpifolia* (brown oak, one of the major forest forming species of higher elevation) and *Podophyllum hexandrum* (may apple, a highly valued medicinal herb of alpine region). Efforts made and success accomplished in hardening and subsequent field transfer of these *in vitro* raised plants have been described. Microclimatic conditions of a simple polytunnel and various bacterial isolates from the native soil have significantly enhanced the success of transplantation of *in vitro* grown plants to the field.

Palni, L.M.S.; Maikhuri, R.K. and Rao, K.S. 1998. **Conservation of the Himalayan Agroecosystems: Issues and Priorities.** *Report on the International Meeting on Himalayan Ecoregional Cooperation, Technical Paper (V)*: 253-280. G.B. Pant Institute of Himalayan Environment & Development, Kosi-Katarmal, Almora 263 643, U.P., India. [AGROECOSYSTEM; BIODIVERSITY; ECO-TOURISM; LIVESTOCK; SOCIO-ECONOMIC]

Traditional agroecosystems of the Himalayan region are closely interlinked with the livestock, forest and rangelands, and are of prime importance for the sustenance of local communities. Agroecosystems are essentially man-made ecosystems and reflect evolution of human culture; they are geared to meet the basic human needs of food, fodder, fibre, fuel, fertiliser, timber and medicine as well as providing economic benefits through commodity crops. The significance of agrobiodiversity as a key component in maintaining the life and culture of the local people has been well recognised world-wide. Biodiversity is a source of resilience and regeneration, and is necessary for the sustainability of agroecosystems. Traditional societies are, in general, more conservation-oriented and follow basic moral guidelines required for mutual co-existence with nature. These values of sustainability are deeply rooted in those cultures that are based on the concepts of collective survival, social equity, and there is a symbiotic relationship between the ecology of the region and traditional resource use practices. The agriculture is biomass based, and the mountain farming systems are diversity rich and multicomponent in nature. The functional agroecosystem comprises forests, cropland, livestock and the household as the major components in organic relationship with each other. During the recent past, as a result of rapid socio-economic and cultural changes and various environmental perturbations, the biodiversity of Himalayan agroecosystems in terms of plants, livestock, insects and soil macro and micro organisms has eroded steadily and significantly. The loss of biodiversity or maintenance of monoculture leads to an increase in ecological vulnerability and unsustainability. Erosion in the Himalayas has caused economic losses, jeopardised productivity, increased vulnerability to climate and other stresses, raised risks for the individual farmers, and has undermined stability of agroecosystems and led to external social costs. Thus, the loss of biological diversity and its impact on the sustainability of Himalayan agroecosystems is emerging as a major cause for concern. Growing awareness of this global problem has prompted increased attention to the need to understand the nature of problems caused by decline in biodiversity. The task does not stop here; it is imperative to study indigenous knowledge and traditional practices for their value in conserving biodiversity and to suggest appropriate technologies and policy options to meet the challenges of biodiversity loss. Efforts to conserve traditional biodiversity-based Himalayan

agroecosystems, will require creation of incentives, a redefinition of agricultural policies, appropriate institutional arrangements, human capacity building and much greater involvement of local people. The gender dimensions of biodiversity conservation and management must also be addressed. Priority interventions for the conservation and management of biodiversity in different agroecosystem types must be identified taking into account the socio-economic conditions and cultural traditions of the people and mountain specificities. Furthermore, in the Himalaya, there is room for the integration of agroecosystem biodiversity with production and promotion of "health/Organic" foods and eco-tourism which can contribute to long-term *in-situ* conservation.

Pandey, A.; Durgapal, A.; Bisht, D. and Palni, L.M.S. 1998. Microbial inoculants for improved plant performance in Himalayn region. *Research for Mountain Development*: 253-272. G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, India; Dept. of Bioscience and Biotechnology, Banasthali Vidyapeeth, Banasthali, Tonk, Rajasthan 304 022, India. [CEDRUS DEODARA; MICROBIAL INOCULANTS; SEED GERMINATION; SIKKIM HIMALAYA; SOIL MOISTURE]

Free living as well as symbiotic plant - microbe associations have been studied and a select number of microbes have been used as inoculants for improved plant performance. The effectiveness of such inoculants depends on three main factors, microbial strain, plant cultivar and the environment/area of initial isolation and use. In a field trial, conducted at various elevations in Sikkim Himalaya, one of the bacterial inoculation(s) resulted in 1.15-fold increase over control in maize yield at a subtropical site. Contrary to this, such beneficial effect was not observed at a temperate location. These and other experiments indicate the need for the isolation of native microbes, that can be developed as potential inoculants for temperate locations. In this laboratory, microorganisms including bacteria, actinomycetes and fungi, are being isolated, screened and characterized for developing promising inoculants for mountain areas. The experiments have been conducted on local crops, tea and coniferous species. *Bacillus* spp. due to endospore forming nature and *Pseudomonas* spp. due to survival at low temperature appear highly promising. *Trichoderma* spp. is another potential candidate amongst various screened fungi. Microbial inoculants have been successfully tested and found to improve laboratory to land transfer and subsequent survival of tissue culture raised tea plants. In summary, the beneficial effects are observed mainly in terms of (1) improved establishment (2) biocontrol, and (3) plant growth promotion.

Pandey, Anita and Palni, L.M.S. 1998. Isolation of *Pseudomonas corrugata* from Sikkim Himalaya. *World Journal of Microbiology & Biotechnology*, 14: 411-413. Environmental Physiology and Biotechnology, G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, India. [NON-FLUORESCENT PIGMENT; PSEUDOMONAS CORRUGATA; SIKKIM HIMALAYA; SOIL BACTERIA]

Two isolates of *Pseudomonas corrugata*, *P. corrugata* 1, a rhizosphere associate, and *P. corrugata* 7, a rhizoplane associate have been isolated and characterized from maize soils; these isolates are from the subtropical and temperate regions, respectively in Sikkim Himalaya. The two isolates have been found to be positive for: (i) production of antifungal compounds; (ii) phosphate-solubilizing activity; (iii) nitrogenase activity; and (iv) growth at 4°C under laboratory conditions. These bacteria produce a non-fluorescent yellow pigment, particularly at lower temperature. Both of the isolates seem to be well adapted to temperate conditions.

Pandey, Anita and Palni, L.M.S. 1998. Microbes in Himalayan soils: Biodiversity and potential applications. *Journal of Scientific & Industrial Research*, 57: 668-673. Environmental Physiology and Biotechnology, G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, India. [FUNGAL ISOLATE; MICROORGANISM; NITROGEN FIXATION; SOIL MICROBES]

Microbial analyses of soil samples from three altitudes, viz. Kamrang, 1200 m; Chamgaon, 1600 m and Jaubari, 1990 m amsl, in Mamlay watershed, Sikkim are reported. Three groups of microorganisms, viz. actinomycetes, fungi and bacteria (including *Pseudomonas*, *Bacillus* and a pigmented group of bacteria) are taken into consideration. In general, microbial populations decreased with increasing altitude. In the case of bacteria and actinomycetes, a sharp and statistically significant decline is recorded ($P < 0.05$) between

Chamgaon and Jaubari. *Bacillus*, a group of endospore forming bacteria, does not show much difference in the number of colony forming units for the tree elevations. *Pseudomonas* and other pigmented bacterial populations increase with the increasing altitude, probably indicating their adaptability to higher altitudes. A large number of microbial species have been isolated, are being maintained, and studied for various properties, e.g. antimicrobial activity, phosphate solubilising and N-fixing ability. These soils seem to have a great potential for screening efficient strains of microorganisms having antimicrobial and phosphate solubilising properties, especially those adapted to the higher altitudes. For example, a fungal isolate, *Paecilomyces lilacinus* has shown a higher degree of phosphate solubilising activity at 10° than at 24°C. Similarly, amongst bacteria a number of *Pseudomonas* strains are found to be well adapted to higher altitude soils and have exhibited antifungal, phosphate solubilising and plant growth promoting properties. Some of the strains of *Pseudomonas* are able to grow at 4°C and also have N-fixing ability, *albeit* lower than the well known N-fixing bacteria. A thorough understanding of biodiversity of soil microbes of the Himalayan region is likely to lead to several potential applications for enhancement of plant performances in the hilly regions. Some of the isolates are being tested as possible inoculants for plants grown in the hills.

Pandey, Anita and Palni, L.M.S. 1999. **Rhizosphere microbiology of Tea.** *Global Advances in Tea Science*: 555-562. G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [MICROFLORA; SEEDLING; SOIL MOISTURE; TEA ROOTS]

The rhizosphere of established tea bushes contains a number of distinguishing features: *viz.* the negative rhizosphere effect; relatively higher antagonistic activity around tea roots, and; lowering of soil pH in the rhizosphere. These findings are based on the experiments carried out at five study sites - Baanuri Tea Experimental Farm, Palampur, H.P.; Mansimble Tea Estate, Palampur, H.P.; Temi Tea Estate, Sikkim; Singell Tea Estate, Kurseong, West Bengal; and Pant Tea Estate, Bhowali (Nainital), U.P. All the sites are located in the Himalayan region and have a monsoon climate; some experience snowfall as well. Various edaphic and climatic factors and interaction between tea roots and the soil collectivity resulted in the development of a very microbial community. *Bacillus spp.* amongst bacteria, species of *Penicillium* and *Trichoderma* amongst the fungi and, several species of *Streptomyces* amongst the *actinomycetes* appear to survive and dominate the established tea rhizosphere. Furthermore, the tea rhizosphere favoured growth of microbes which are known to produce strong antibiotics, and have a potential as biocontrol agents. Tea (*Camellia sinensis*) is an economically important and major plantation crop of India. A striking features of the tea plant is that is a small tree which is maintained as a shrub by continuous pruning cycles of various durations. From a microbiologist's point of view an established tea rhizosphere provides an excellent site for studying microbial interaction under natural conditions in a specific environment, more so due to the long lived nature of tea plants. Recent work on tea soils has revealed interesting observations related to microbial activities in the tea rhizosphere (Pandey & Palni, 1996). The study was carried out in and around Palampur in Kangra district, Himachal Pradesh, India, during November 1990 to March 1992. Tea plantations (mainly Chinary type) in the Kangra Valley cover a geographical area of about 880 sq. Km and are located between 32.03° and 32.20°N and 76.37° and 76.80°E at 1000-1700 m above mean sea level in the mid-hills. In this article emphasis has been laid on three main aspects of tea rhizosphere (1) the rhizosphere effect (2) the role of antagonistic activities in the rhizosphere and (3) the influence of environmental factors on microbial community in tea rhizosphere. These findings have also been confirmed at three more sites (1) Temi Tea Estate, Sikkim (2) Singell Tea Estate, Kurseong, W.B., and (3) Pant Tea Estate, Bhowali, U.P.

Pandey, H. and Joshi, G.C. 1998. **Phytosociological analysis of forest communities between 1500 and 2000 m altitude at Kasar Devi Hill in Kumaun Himalaya.** *Journal of Hill Research*, 11(2): 139-144. Laboratory of Ecology, Department of Botany, Kumaun University Campus, Almora 263 601, U.P.; G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [CEDRUS DEODARA; DIVERSITY; PHYTOSOCIOLOGICAL ANALYSIS; PINUS ROXBURGHII; SEEDLING]

The present study deals with the Phytosociological analysis of forest stands located along an altitudinal gradient of 1500-2000m. Based on IVI chir pine (*Pinus roxburghii*) (stand 1,2,4 & 5), deodar (*Cedrus deodara*) mixed chir pins (stand 3), pine mixed oak (*Quercus leucotrichophora*) (stand 4), oak

(stand 6) and oak dominated mixed broad leaved (stand 7) forests were identified. *P. roxburghii* was the dominant species at lower elevation of east and south aspect and *Q. leucotrichophora* at higher elevation of north aspect. The regeneration of *C.deodara* was very poor in all the stands, while of *P. roxburghii* was better on the south and east aspect and of *Q. leucotrichophora* on north aspect. The distribution pattern indicated that most of the species in different stands are contagiously distributed. Across the stands tree density, total basal cover and diversity ranged from 530-910 trees/ha, 22.45-61.70 m²/ha and 1.35-2.85, respectively.

Patnaik, S.S. 1999. **Status of tigers outside the protected areas in Mizoram.** *Indian Forester*, 125(10): 1031-1039. Principal Chief Conservator of Forests, Mizoram, Aizawl. [CONSERVATION; PLANT SPECIES; PROTECTED AREA; WILDLIFE]

The author has listed 31 new records of birds from New Forest campus (4.4 km²) and adjoining 'Tons' river bed, located at Dehradun in Northern India, along with their status, general abundance, habits and habitats. With these new additions the annotated check list of birds of New Forest, recorded since 1944, now comprises of 292 species. The avifaunal richness of New Forest campus is mainly attributed to the large variety of habitats, both artificial and natural, and numerous, indigenous as well as exotic, plant species found here.

Prasad, Kamal 1999. **Elephant conservation, management and protection of human interests.** *Indian Forester*, 125(10): 1040-1046. 8-B, Luxmi Road, Dehradun, U.P., India. [BIOMASS; CONSERVATION; DEGRADATION; MANAGEMENT; NATIONAL PARK]

The Dehradun Shivalik belt is the North-Western limit of the vast range of the Asian Elephant. It is also a region which has been heavily populated in recent years and, this, along with highways, hydro electric schemes on the Ganga, has greatly disrupted and reduced the effective habitat and migrations of the resident Elephants. Elephant-man confrontations have increased to unacceptable levels with Elephants wreaking havoc on cultivations. The Rajaji Park area which even 16 years after notification has not been declared a National Park, has been bisected into distinct sectors by highways, power channels and settlements and it can no longer sustain the large population of Elephants using its tract. This article seeks to encourage thinking on new lines to mitigate this problem. The ideas and solutions suggested herein are entirely author's own.

Rajendran, K.; Rajendran, C.P.; Jain, S.K.; Murty, C.V.R. and Arlekar, J.N. 2000. **The Chamoli earthquake, Garhwal Himalaya: Field observations and implications for seismic hazard.** *Current Science*, 78(1): 45-51. Centre for Earth Science Studies, P.B. No. 7250, Akkulam, Thiruvananthapuram 695 031, India; Department of Civil Engineering, Indian Institute of Technology, Kanpur 208 016, India. [EARTHQUAKE; SEGMENT; SEISMIC HAZARD]

The Chamoli earthquake in the northern part of Uttar Pradesh is an important event from the point of view of seismic hazard and risk assessment in the Himalaya. Tectonically, it is significant due to its location in the 'central seismic gap', a 700-km-long segment between the 1905 Kangra (M 8.6) and the 1934 Bihar (M 8.4) earthquakes. Occurrence of two moderate earthquakes (1991 Uttarkashi and 1999 Chamoli) within a period of nine years naturally raises concern about the seismogenic potential of the region. In this paper we present observations made during the post-earthquake survey around Chamoli, and address some issues regarding the regional seismic hazard.

Rawat, D.S.; Joshi, M.; Sharma, S.; Rikhari, H.C. and Palni, L.M.S. 1998. **Simple technologies for rural development: A case study from Haigad Watershed in Kumaun Himalaya.** *Research for Mountain Development*: 65-82. G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [AGRO-FORESTRY; ECO-FRIENDLY; POLYHOUSES; SOIL FERTILITY; WATER CONSERVATION]

Rainfed agriculture in ecologically fragile landscape of the Himalayan region have been suffering from increased degradation. This has led to loss of biodiversity, reduction in soil fertility and agricultural productivity, resulting in increased out migration of youth, mainly in search of livelihood. In order to cope up with these problems, an attempt has been made to develop micro-level planning on area specific land use for environmental management. The tested area for various activities represented an elevational range of 1160 to

2338 m amsl in Indian Central Himalaya, generally known as the 'problem zone' due to concentrated population. Based on the primary information, i.e., existing land use practices, environmental problems and feed back obtained from scientists and farmers, an eco-friendly alternative model was formulated and demonstrated in the farmer's field in order to accomplish optimal land utilisation and sustainability. All the activities were carried out by ensuring People's participation. People's perceptions about various programmes were found to be quite satisfactory as shown by the farmer's keen interest in adoption of demonstrated technology packages and request for planting materials (saplings/seeds) of superior quality and polythene for polyhouses, polytunnels and bio-composting.

Samal, P.K.; Rawat, D.S.; Farooque, N.A.; Pant, R.; Pant, P.; Total, Y.S.; Satyal, G.S. and Parihar, D.S. 1998. **Tribal development: Problems and prospects.** *Research for Mountain Development*: 165-194. G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [LAND-RESOURCE; POLYANDRY; SOCIO-CULTURAL; TRIBAL DEVELOPMENT]

Development of tribes has been a challenging task for the Republic of India. Starting with the post independence era, planning and efforts for the development of tribal people have been accelerated in the recent times and a number of intervention packages have been designed and implemented. By and large, the emphasis of such packages has been towards assimilation of tribal people in the main stream without much regard and understanding of the needs of these communities, their social structure, culture and rich heritage. Consequently, the expected goals have not been achieved and the packages have largely remained ineffective. This study was carried out in the central Himalayan region of India covering two tribal communities viz., the Jaunsaries & the Bhotias, by the Institute to understand integrated nature of tribal culture & its influences on resource use & management, tribals' perception of development linkages between culture and development, impact of planned interventions, etc. In brief, it aimed at addressing the imaginary & realistic goals of sustainable development, i.e., is sustainable development in tribal areas merely a subject of argument or an objective to achieve? Data that never been available before the two tribal communities have been collected on a number of facets such as physical environment, demographic composition & variables, socio-cultural milieu, economic structure & resource use pattern, political structure, village institutions, planned interventions and the changes in the above over a period of 30-50 years. The other major area of data coverage was the tribal peoples' perception of development, their knowledge on environment & its conservation and their felt-needs which would be prioritizing development goals. Finally, a framework for tribal development has been suggested focusing on policy planning based on data and peoples' perception of development.

Samal, P.K.; Topal, Y.S. and Pant, Pushpa 1999. **The socio-economic and demographic behaviour of Van-Rajis- a primitive and nomadic tribe in Central Himalayan of India.** *Man in India*, 79(3&4): 241-252. G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [CENTRAL HIMALAYAN; DEMOGRAPHIC BEHAVIOUR; SEX RATIO; SOCIO-ECONOMIC; VAN-RAJIS]

The Rajis or Van-Rajis or Van-Rawats, socially and economically, are the most under-developed tribal community of Central Himalayan region of India. They are a primitive and numerically very small tribal community. Other than being primitive and forest dweller, the tribe is nomadic which prevented a complete and true enumeration of its population, as studies carried out have reported difference in population for the tribe for a single period. Though, there are few ethnographic studies, demographic behaviour of the tribe is totally unknown. This study was undertaken for a true enumeration, and to establish socio-economic realities and demographic behaviour of the tribe. It was found that all the families of the tribe are below poverty line and nearly thirty per cent of the populace still continues nomadism. Despite a commendable effective literacy rate (35.06), only three persons are engaged in service sector. The annual growth rate which was 3.31 during the period 1981-1991 has declined, disturbingly, to 1.24 during the period 1991-1996, in contrast to high fertility behaviour.

Samant, S.S.; Dhar, U. and Rawal, R.S. 1998. **Biodiversity status of a protected area in West Himalaya: Askot Wildlife Sanctuary.** *International Journal of Sustainable Development and World*

Ecology, 5: 194-203. G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [AGRO-FORESTRY; CONSERVATION; DIVERSITY; ENDEMIC; NATIVE; THREATENED]

Biodiversity of a protected area of West Himalaya (Askot Wildlife Sanctuary) was studied and analysed for landscape, faunal and floral diversity. The forest and pasture land, ideal habitats for the flora and fauna, covered nearly 52% and 12%, respectively, of total reported area. Among the fauna Himalayan musk deer (*Moschus chrysogaster*), thar (*Hemitragus jemlahicus*), snow leopard (*Panthera uncia*), koklas (*Pucrasia macrolophas*), monal (*Lophophorus impejanus*), and snow cock (*Tetragalus tibetanus*) are threatened species. Plant diversity is represented by 1262 species of vascular plants (Angiosperm 1112, Gymnosperm 7, Pteridophytes 143 taxa). Diversity of the species within families, genera, habitats, communities and along vertical gradient zone was analysed. Maximum diversity existed in the family Orchidaceae (120 taxa), genera *Polystichum* (13 taxa), altitude zone (1001-2000 m; 860 taxa), habitat (forest; 623 taxa) and community (Banj oak; 92 taxa). Seventy-one families were found to be monotypic. Species were further analysed for ethnobotanical use (medicine: 70, edible: 55, fodder: 115, fuel: 31, house building: 13 etc.), domesticated diversity (crops: 19, vegetables: 26, fruits: 16), agroforestry or marginal, threatened and endemic diversity. Similarity in species composition within the habitats indicated maximum similarity in areas of shrubberies and alpine meadows/slopes (71.65%) and exposed open/grassy slopes and shady moist places (47.32%). 432 (34%) taxa are native to Indian Himalaya of which 24 are endemics and 235 are near endemics. 65% of taxa are represented in the neighbouring areas and other regions of the globe. Ten taxa occurring in the Sanctuary have, been already recorded in the Red Data Book of Indian Plants. Conservation and management of species is focused.

Samant, S.S.; Rawal, R.S.; Adhikari, B.S. and Dhar, U. 1998. Establishment and maintenance of a functional arboretum at Kosi-Katarmal, Almora, Kumaun Himalaya. *Research for Mountain Development*: 289-318. G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [ARBORETUM; GERMINATION; POLYHOUSES; SEEDLING]

Attempt to establish and maintain a functional arboretum at Kosi-Katarmal are presented. The area was surveyed to study the diversity of species and habitats and data were analysed for species and habitat diversity to know the existing status of plants. A total of 230 species of vascular plants (Angiosperms: 205 spp; Gyrhnosperms: 4 spp and Pteridophytes: 21 spp) belonging to 85 families and 89 genera were reported. Among all the families species richness was maximum in the family Asteraceae (25 spp). Infrastructure such as glass-house, net-house, poly-house, nursery and water harvesting tank were developed to facilitate the research activities. Seeds and cutting of various species were collected and monitored for germination and growth performance. Seeds of over 10 species showed > 80% germination and cuttings of 9 species showed > 70% rooting and survival. The percent germination of the species (with poor germination in ordinary sowing) was improved through presowing treatments. Growth performance of species was monitored in the nursery, glass-house and net-house to identify the ideal conditions for the development of respective species. Apart from the existing diversity of the area, over 160 species of trees, shrubs, herbs and pteridophytes including rare-endangered, endemic, ecologically and economically important species are being maintained. The seedlings developed in the arboretum nursery are distributed to local inhabitants through various research and development activities for the restoration and conservation of community and college lands. Further, efforts are continuing for the enrichment and development of the arboretum sites.

Saran, Sameer; Sharma, Subrat and Roy, P.S. 2000. Extraction and refinement of landuse/landcover information from satellite digital data using fast Fourier transformation in spatial frequency domain. *Current Science*, 78(1): 87-90. Indian Institute of Remote Sensing, 4 Kalidas Road, Dehradun 248 001, India; G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, India. [LAND-COVER; LAND-USE; SATELLITE DATA; SPATIAL FREQUENCY]

Applicability of fast fourier transformation (FFT), which deals with a co-ordinate space known as spatial frequency domain, has an advantage in the process of feature extraction for different landuse/landcover classes over the single supervised classification. The study deals with the extraction of low frequency component from the power or amplitude spectrum by applying inverse Fourier transform to

convert back into spatial domain in the form of image. The derived Fourier transformed and filtered image is partially devoid of radiometric error which generally prevails in the remotely sensed data due to the atmospheric effect. This can be further minimized, whereby enhancing the texture of the image. The classified map extracted from the FFT image provides a better estimation of the landcover classes than the supervised classification alone. This method has applicability for mapping of natural resources and monitoring them.

Sarkar, I. and Saraf, A.K. 2000. **Some observations of the Chamoli earthquake-induced damage using ground and satellite data.** *Current Science*, 78(1): 91-97. Department of Earth Sciences, University of Roorkee, Roorkee 247 667, India. [EARTHQUAKE; HYPOCENTRAL ZONE; LANDSLIDE; MECHANISM; SATELLITE DATA]

The havoc caused by the Chamoli earthquake of 29 March 1999 in the Alaknanda-Mandakini river valley region of Garhwal Himalaya was surveyed extensively and systematically, both in the field and from satellite data. The aim was to identify plausible patterns in the damage, so that observational constraints, useful for enhanced understanding of the earthquake and its related processes, could be established. This study provides evidences and constraints for reliable identification of (i) the meiseoseismal zone of the earthquake, (ii) the possible up-dip and down-dip sections of the causative fault, (iii) the hypocentral zone, (iv) the fault plane and faulting mechanism, and (v) the possible geological causes responsible for induced landslides to occur mainly on the southern slopes of the mountains.

Sharma, Subrat; Rikhari, H.C. and Palni, L.M.S. 1999. **Conservation of natural resources through religion: A case study from Central Himalaya.** *Society & Natural Resources*, 12: 599-612. G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [CONSERVATION; HIMALAYA; NATURAL RESOURCE; RELIGION; TEMPLE]

This study explores the method early settlers in the Central Himalayan region used to develop/adopt an indigenous system for conservation of bioresources. Most of the commonly used tree species were protected/planted in sacred groves. All protected species were located within the boundaries of worship points in village settlements. Today the "protected resource" does not enjoy the same status outside the boundary of the temple or worship point. Thus, it appears that early settlers established these religious points as in situ germplasm preservation/collection centers to conserve natural resources, sustain the daily requirement of villagers, and provide the "elite" stock material for multiplication. This innovative and intelligent practice has been an effective means of conservation, in total harmony with the environment, and seems to have persisted through generations.

Singh, Arun P. 1999. **Birds of new forest, Dehradun : Recent sightings.** *Indian Forester*, 125(10): 1035-1039. Forest Entomology Division, Forest Research Institute, Dehradun, U.P., India. [BIRDS; EXOTIC; PLANT SPECIES]

The author has listed 31 new records of birds from New Forest campus (4.4 km²) and adjoining 'Tons' river bed, located at Dehradun in Northern India, along with their status, general abundance, habits and habitats. With these new additions the annotated check list of birds of New Forest, recorded since 1944, now comprises of 292 species. The avifaunal richness of New Forest campus is mainly attributed to the large variety of habitats, both artificial and natural, and numerous, indigenous as well as exotic, plant species found here.

Vyas, P.; Bisht, M.S.; Bhuchar, S.; Sharma, S. and Palni, L.M.S. 1999. **Polypit: An improved technique for raising nursery plants.** *Journal of Sustainable Forestry*, 8(1): 43-59. G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, U.P., India. [BIOMASS; MICRO-CLIMATIC CONDITION; NURSERY PLANT; POLYPIT]

Availability of quality planting material in the Himalayan region is one of the major constraints limiting the progress of afforestation programmes and rehabilitation of degraded/wastelands. The poor economy, difficult terrain and inaccessibility prohibits the use of high-tech controlled condition glasshouses for raising tree saplings. In view of this, experiments were done to examine the efficacy and practicability of

four simple micro-climate conditions viz., polypit, polyhouse, chhappar and open (control). Based on the performance of plants of nine species maintained under these conditions, in terms of growth, development and photochemical efficiency, best performance was recorded for plants kept in the polypit. Polypit which can be aptly named as a "poorman's growth chamber" was designed to raise tree saplings and protect them from the climatic vagaries. In winter the temperature inside the polypit was found to remain above 8.0°C whereas the ambient temperature dropped to around - 2°C. In addition to soil temperature being higher, the polypit was found to be excellent for maintaining high humidity, and also provided CO₂ fertilisation; CO₂ levels reached two to four times that of ambient during the night. Thus polypit provided conducive environment for the growth of plants and also afforded protection to frost sensitive species; chlorophyll a fluorescence data indicated that such plants experienced much less stress.

Wilson, J. Warren; Palni, L.M.S. and Wilson, P.M. Warren 1999. Auxin concentrations in nodes and internodes of *impatiens sultani*. *Annals of Botany*, 83: 285-292. Division of Botany and Zoology, Faculty of Science, Australian National University, Canberra, ACT 0200, Australia; G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, India; Plant Biology Group, Research School of Biological Sciences, Australian National University, Canberra, ACT 0200, Australia. [ABSCISSION; AUXINS; IMPATIENS SULTANI; INDOLE-3 ACETIC ACID; NODE]

Greater concentrations of auxin at nodes than in internodes, resulting from some nodal barrier to basipetal transport, have long been postulated as the cause of early differentiation of initially isolated xylem and cambium at the nodes. However, this study, using [¹⁴C] indole-3-acetic acid (IAA) applied apically and gas chromatography-mass spectrometry, found that in stems of *Impatiens sultani* the IAA concentrations (per unit f.wt) at nodes were similar to those in adjacent internodes, though a little greater at nodes if expressed per unit length of stem and a little less per unit d. wt. By contrast, in decapitated shoots and in stem explants of dicotyledons, loss of the apical source of basipetally flowing auxin can result in auxin drainage with some auxin retention in the uppermost remaining nodes. When [¹⁴C]IAA was applied apically to shoots for 4 h and stem explants were excised, the explants had no nodal accumulation initially whereas comparable explants incubated for 20 h revealed significant nodal accumulation. If decapitation leads both to nodal auxin accumulation and to adventitious abscission just above the node, this fits the hypothesis that abscission sites are positioned where auxin concentration decreases locally in the apical direction. Difficulties in quantifying nodal auxin dynamics are discussed, and some crude estimates of metabolic rates and locations of the auxin are presented.

News & Views

Compiled by S.N. Nandy, D.S. Negi, and S.K. Sinha

G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, India

Climate inversion makes Himachal hills warmer

The climate inversion for the second consecutive year has made the hill not only warmer than most places in the plains of north India but also fog free. Locals and tourists can be seen enjoying the bright sunshine in Himachal Pradesh, but the prolonged dry spell is giving cause for concern to fruit growers. Particularly the apple belt is the most worried lot, as lack of snow in the last few years has already ruined the apple crop.

THE HINDUSTAN TIMES: January 6, 2000

Sunny Darjeeling faces water crisis

The unusual sunny weather for past few days might delight the tourist in Darjeeling hills, but both residents and the civic authorities fear an impending water crisis. The reason being that, there has been little rainfall since the monsoons ended here. The first sign of water crisis are already visible, as supplies from the local municipality are available only once in three days.

THE STATESMAN: January 6, 2000

Arunachal hydel projects to improve power situation

The 21,000 mw hydel power projects of Dehang and Subansiri in Arunachal Pradesh, would bring about significant changes in the power sector on their completion within a decade. The world's biggest hydel power project at Dehang, three dams would be created at Puging (11,000 mw), Kaylng (700 mw), and Rotung (1700 mw). Work for the two giant projects has been entrusted to National Hydro Power Corporation (NHPC) and the centre has asked to complete the first phase of projects by 2008 and the remaining phases by 2012.

THE FINANCIAL EXPRESS: January 12, 2000

Parbati project 'can meet' power crisis

The 800 mw Parbati Hydroelectric Project (stage II), can go a long way in easing the power crisis, provided the National Hydroelectric Power Corporation (NHPC) takes up work on a war-footing. Parbati, a tributary of the river Beas, has an identified hydel potential of 2051 mw. The project will be executed in three stages by the NHPC under an agreement entered into with the Himachal Pradesh Government last year. Considering the feasibility, stage II will be taken up first for execution. The work of remaining stages I and III with capacities 750 and 501 mw respectively, would be taken up later.

THE TRIBUNE: January 17, 2000

HP's go-ahead for felling

Plagued with perennial financial crisis, the fund starved Himachal Pradesh Government has finally given the go-ahead for felling of green trees. The decision, to lift the 16-year-old moratorium on felling of green trees was taken by the Cabinet last month, is likely to double the state's forest revenue from the next financial year. However, felling will be carried strictly in accordance with the forest working plans for each division duly approved by the Centre as laid down by the Supreme Court. As a result over one lakh cubic metres of additional timber will be extracted from the state's forest annually.

THE TRIBUNE: January 21, 2000

Promotion of medicinal plants necessary for rural uplift

Promotion of cultivation of medicinal and aromatic plants was needed to uplift the living standards of the rural people, said science and technology minister of Sikkim. Inaugurating a four-day training programme on production and processing of medicinal and aromatic plants at Gangtok, the minister said that the state has excellent climatic condition for cultivation of improved and high-yielding varieties of those plants and asked the farmers to adopt these techniques.

THE ASSAM TRIBUNE: January 22, 2000

Mining poses ecological threat

Palampur, a famous tourist resort and one of the beautiful town of Himachal Pradesh, has been facing serious environmental threat because of reckless and unscientific mining. In the absence of political and administrative 'will' the deforestation and mining is still going on unchecked in the state. At present the state government has no policy for the grant of mining lease in the state resulting in largescale felling of trees, barrenness of hills and heavy pollution. Besides, the government is also losing huge revenue causing loss of the state exchequer.

Ravinder Sood for THE TRIBUNE: January 26, 2000

Jhum farming threatens Nagaland bio-diversity

Nagaland's rich agro-biodiversity is under threat due to the age-old practice of 'slash and burn method of cultivation', popularly known as jhum cultivation. About 80% of the Nagas depend on jhum cultivation. After two consecutive years, they leave the field for the next nine years for the jhum cycle to come. This practice has led to disastrous consequences for the eco-system in the state. However, an agro-forestry project called Nagaland Environment Protection and Economic Development (NEPED) has been operating since 1995. The main objective of NEPED is not to leave the jhum field fallow after cultivation by planting trees before jhum cycle comes, thus make jhum cultivation remunerative.

THE STATESMAN: January 31, 2000

Plan to construct airstrip annoys environmentalists

The Uttar Pradesh state government's decision to construct an airstrip near the famous Valley of Flowers has not gone down well with social activists and environmentalists of the area. The area located near the famous Sikh shrine of Hemkund Sahib, is a virtual treasure trove of countless varieties of high altitude alpine flowers. The construction of the airstrip is apparently aimed at providing additional facilities to pilgrims as well as tourists visiting the area. However, environmentalists fear that the construction of the airstrip would harm the fragile ecology and expanse of flower meadows.

THE TIMES OF INDIA: January 31, 2000

Wildlife management poor

Despite a vast network of sanctuaries, zoological parks and mini zoos, the management of the ever-dwindling wildlife reserves in Himachal Pradesh continues to be a state of neglect. Irrational and inadequate set-up of the wildlife wing coupled with the shortage of funds and trained manpower are coming in the way of the effective management of wildlife. While the Centre has been insisting that each state should have an independent set-up for the proper management of wildlife, in Himachal the control of many sanctuaries remains with the territorial wing.

THE TRIBUNE: January 31, 2000

भेद्य विकास योजना खतरे में

उत्तर प्रदेश के पर्वतीय क्षेत्र में जड़ी-बूटियों के उत्पादन, शोध और विकास के लिए पचास वर्षों पूर्व स्थापित भेद्य विकास योजना का अस्तित्व खतरे में है। पर्वतीय क्षेत्र में जड़ी-बूटियों के विकास की गहन सम्भावनाओं को देखते हुए सरकार ने 1949 में सहकारिता विभाग की भूमि पर भेद्य विकास योजना की स्थापना की। योजना का मुख्य उद्देश्य औद्योगिक वनस्पतियों का शोध, विकास, संग्रहण और विपणन करना था। 1987 में इसे भेद्य एवं जड़ी-बूटी विकास योजना का नाम दिया गया। प्रदेश सरकार के गंभीर वित्तीय संकट के दौर से गुजरने से प्रदेश की कुछ संस्थाओं को बंद करने के साथ ही भेद्य विकास योजना को भी बंद करने पर विचार चल रहा है। वर्तमान में जहाँ उत्तराखण्ड की आर्थिक समृद्धि के लिए जड़ी-बूटी विकास के लंबे चौड़े वायदे किए जा रहे हैं ऐसे में 50 वर्षों पूर्व स्थापित भेद्य विकास योजना को अधिक चुस्त-दुरुस्त बनाने के बजाय बंद कर देना उत्तराखण्ड के हित में नहीं होगा।

अमर उजाला: फरवरी 8, 2000

CHANGING LANDSCAPE OF HIMACHAL PRADESH

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The Himachal Pradesh lies in the strategic position of western Himalaya between 30°23' and 33° 13'N latitudes and 75° 43' and 79° 4'E longitudes. It is the third largest state in the Indian Himalaya covering 55,673 km² geographical area and consists about 10.48% of the total area of Indian Himalayan region. The state lies to the south of Kashmir. Tibet (China) is the boundary of the state in the east, Garhwal region of Uttar Pradesh in the south-east, Punjab in the south-west, and in the south it touches the border of Haryana. The state is almost entirely mountainous with altitude ranging from 460 to 6600m above sea level. The region presents an intricate mosaic of mountain ranges, hills, and valleys and known for its natural loveliness. The Dhauladhar range looks in supreme majesty over Kangra valley, while the Pir Panjal, the Great Himalaya and the Zaskar ranges stand guard over Chamba, Lahaul-Spiti, Kullu and Kinnaur. The state is divided into 12 administrative divisions (districts). Table 1 presents the distribution of area, population, economic density of 12 Himachal districts.

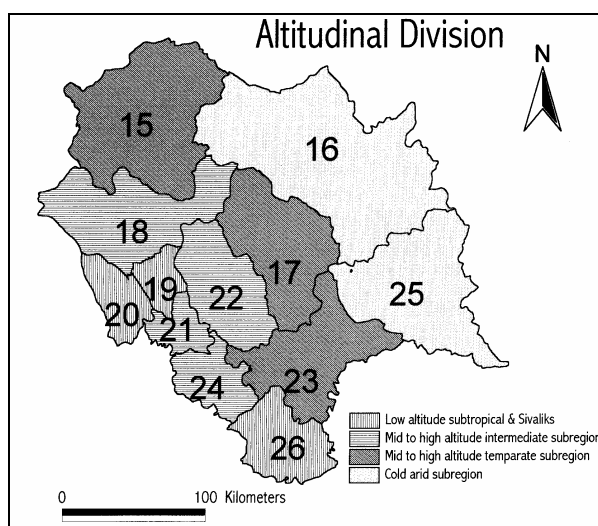


Figure 1. Districts are classified according to the average altitudes are identified by the district codes.

Table 1. Area and population distribution: districts are arranged according to the order of code (15 to 26), whereas area, population, rural population, and economic density are ranked in descending order of respective parameters.

Code - District	Geographical area (km ²)	Population 1991	% of rural population	Economic density 1991	Rank			
					Area	Population	Rural population	Economic density
15 Chamba	6515	393286	92.40	905	3	4	7	3
16 Lahul Spiti	13693	31294	100.00	973	1	12	1	1
17 Kullu	5503	302432	93.05	781	5	9	5	9
18 Kangra	5739	1174072	94.95	917	4	1	2	2
19 Hamirpur	1118	369128	93.85	783	12	8	4	8
20 Una	1540	378269	91.47	761	10	7	8	11
21 Bilaspur	1167	295387	94.33	867	11	10	3	4
22 Mandi	3951	776372	92.82	793	7	2	6	7
23 Shimla	5131	617404	79.57	745	6	3	11	12
24 Solan	1937	382268	87.63	842	9	5	10	5
25 Kinnaur	6553	71270	100.00	774	2	11	1	10
26 Sirmaur	2826	379695	89.97	806	8	6	9	6
Himachal Pradesh	55673	5170877	91.31	825				

Table 2. Population distribution: districts are ranked according to ascending order of exponential trend of population growth

Code - District	Decadal growth rate		% share of total population			Population density [@]				Exponential trend [#]
	1971-81	1981-91	1971	1981	1991	1971	1981	1991	2001*	
16 Lahul Spiti	23.86	-2.51	0.80	0.75	0.61	2	2	2	2	1.0064
19 Hamirpur	24.10	16.17	7.66	7.42	7.14	237	284	330	377	1.0167
25 Kinnaur	16.44	19.69	1.44	1.39	1.38	8	9	11	12	1.0180
20 Una	23.71	19.17	7.55	7.41	7.32	170	206	246	283	1.0187
18 Kangra	21.46	18.50	23.14	23.14	22.71	140	173	205	238	1.0193
23 Shimla	19.90	20.84	12.13	11.94	11.94	82	100	120	139	1.0195
22 Mandi	25.17	20.40	14.89	15.06	15.01	130	163	196	229	1.0207
21 Bilaspur	26.99	19.41	5.63	5.78	5.71	167	212	253	297	1.0210
26 Sirmaur	27.77	23.72	7.08	7.17	7.34	87	109	134	157	1.0221
15 Chamba	21.70	26.40	7.26	7.27	7.61	39	48	60	70	1.0227
17 Kullu	19.49	26.68	5.56	5.58	5.85	35	43	55	64	1.0229
24 Solan	25.25	26.02	6.86	7.09	7.39	123	157	197	233	1.0241
Himachal Pradesh	23.71	20.79	100	100	100	62	77	93	108	1.0203

[@] Rounded off to nearest integer; *Projected figure - linear projection from 1971, 1981 and 1991 census;

[#] Worked out from the decadal growth rate of 1971, 1981, 1991 census and rounded off to four digits after decimal.

The decadal growth rate of Kinnaur, Shimla, Chamba, Kullu, and Solan is increasing in contrast to the state, which exhibit a decreasing decal growth rate over last two decades. The growth rate of Chamba, Kullu, and Solan is higher than (>25%) not only the state's decadal growth rate but also in the context of national average which is 23.85% according to 1991 census.

Table 3. Landuse pattern 1991: districts are ranked according to the descending order of net sown area (%) of the state.

Code - District	Total reporting area (ha)	Percentage distribution of reporting area in major landuse category				
		Net sown area	Forests	Not available for cultivation ¹	Other uncultivated land ²	Fallow lands ³
18 Kangra	577472	21.19(20.99)	40.35(23.27)	21.01(31.70)	15.85(6.87)	1.60(14.62)
22 Mandi	397056	24.01(16.35)	41.62(16.50)	5.95(6.18)	27.70(8.26)	0.72(4.52)
23 Shimla	423335	17.89(12.99)	24.61(10.40)	7.33(8.11)	48.14(15.31)	2.04(13.63)
20 Una	151464	30.06(7.81)	18.92(2.86)	31.99(12.66)	9.70(1.10)	9.34(22.36)
26 Sirmaur	224741	19.26(7.43)	21.65(4.86)	7.55(4.43)	49.40(8.34)	2.22(7.88)
15 Chamba	692419	5.97(7.09)	39.22(27.12)	2.40(4.33)	52.07(27.08)	0.35(3.78)
24 Solan	180470	22.84(7.07)	10.97(1.98)	11.65(5.49)	51.79(7.02)	2.75(7.86)
19 Hamirpur	109973	35.36(6.67)	18.19(2.00)	28.47(8.18)	10.19(0.84)	7.75(13.48)
17 Kullu	50103	72.61(6.24)	-	16.02(2.10)	6.51(0.24)	4.87(3.86)
21 Bilaspur	115438	27.83(5.51)	9.81(1.13)	18.43(5.56)	41.40(3.59)	2.53(4.62)
25 Kinnaur	223422	3.40(1.30)	9.54(2.13)	16.53(9.65)	69.66(11.69)	0.87(3.09)
16 Lahul Spiti	215628	1.46(0.54)	36.02(7.76)	2.85(1.61)	59.59(9.65)	0.09(0.30)
Himachal Pradesh	3361521	17.34(100)	29.79(100)	11.38(100)	39.61(100)	1.88(100)

Figures within () indicate the percentage contribution of individual district to the respective landuse pattern of the state. ¹Land under non-agricultural uses, barren and uncultivable;

²Includes permanent pastures, grazing, miscellaneous tree crops & groves, and culturable waste land;

³Comprises current fallows and other than current fallows.

Table 4. Compound growth rates of landuse (1966-67 to 1990-91): districts are arranged in descending order of compound growth rate of net sown area

Code-District	Area by village papers	Forest	Barren & uncultivated land	Non-agriculture use	Permanent pastures & grazing land	Misc. tree crops & groves	Culturable waste	Current fallows	Other fallows	Net sown area
16 Lahul Spiti	0.365	4.935	10.058	-1.343	-1.093	2.090	9.385	-1.482	120.85	1.100
22 Mandi	0.131	0.486	-0.693	2.404	-0.808	7.841	-0.182	1.577	2.433	0.658
23 Shimla	1.669	3.148	1.029	2.335	1.926	2.348	-0.680	0.768	3.332	0.544
17 Kullu	0.334		3.400	-3.199		-4.106	3.150	-0.484	135.98	0.518
20 Una	3.696	-0.605	9.885	-2.751	2.502	161.843	-	-1.487	159.27	0.404

							5.247		8	
18 Kangra	0.796	0.780	1.109	1.696	4.144	147.40	3.018	-7.209	40.059	0.329
21 Bilaspur	-1.937	-0.298	4.124	-0.722	-0.656	5.381	2.472	2.134	5.864	0.309
15 Chamba	-5.471	6.379	4.888	-0.957	-2.425	16.205	-	0.474	0.517	0.292
							0.443			
26 Sirmaur	-1.585	0.156	0.486	7.445	-0.174	-0.277	-	1.972	3.507	0.195
							0.556			
25 Kinnaur	16.146	50.70	15.904	12.28	29.162	22.316	2.571	2.168	7.318	-
										0.459
19 Hamirpur	-9.797	-0.527	-1.458	0.693	-5.516		1.169	-0.438	134.56	-
									9	3.862
24 Solan	8.266	-0.132	0.749	-3.150	1.235	13.425	1.861	-0.153	4.227	-
										9.909
Himachal Pradesh	0.694	2.322	2.245	0.220	-8.688	-0.205	-	-1.613	11.197	0.359
							0.606			

In the period of 1967-91 the state exhibit a major change in its landuse pattern. Other than current fallows, forest cover and barren and un-cultivated land has increased while permanent pastures and grazing land has reduced significantly. The net sown area and area put to non-agricultural use has increased marginally. Lahul Spiti district ranked first where the forest cover and net sown area has increased considerably, whereas Solan and Hamirpur are the worst affected districts, where both the net sown area as well as forest cover has decreased significantly.

Table 5. Agricultural density and area per capita of agricultural land (1981-91): districts are arranged according to the descending order of decadal changes (%) of agricultural density

Code - District	Physiological density			Agricultural/cultivable area per capita			% of population engaged in primary activities (1991)
	1981	1991	% change	1981	1991	% change	
16 Lahul Spiti	1270	933	-26.54	0.078	0.107	37.18	86.2
22 Mandi	677	798	17.87	0.147	0.125	-14.97	93.8
21 Bilaspur	716	891	24.44	0.139	0.112	-19.42	92.7
20 Una	635	830	30.71	0.157	0.122	-22.29	79.3
17 Kullu	618	833	34.79	0.161	0.119	-26.09	93.8
18 Kangra	649	829	27.73	0.154	0.112	-27.27	82.5
15 Chamba	682	960	40.76	0.146	0.104	-28.77	84.7
25 Kinnaur	623	921	47.83	0.160	0.108	-32.50	89.1
24 Solan	580	876	51.03	0.172	0.114	-33.72	82.8
26 Sirmaur	212	484	128.30	0.471	0.206	-56.26	93.0
19 Hamirpur	179	930	419.55	0.558	0.107	-80.82	92.9

Data of Shimla is not available.

The increase in physiological density (1981-91) has aggravated the primary sector only. Almost all the districts are exposed to high agricultural density and significant decrease of per capita agricultural area (1981-91), except Lahul-Spiti district (Figure 2). Hamirpur and Sirmaur are the worst affected districts, where the per capita agricultural area has decreased more than

50% in a decade and more than 90% population engaged in agricultural activities. This calls for an urgent reorientation of planning programmes giving emphasis on the development of secondary and tertiary sectors of the economy.

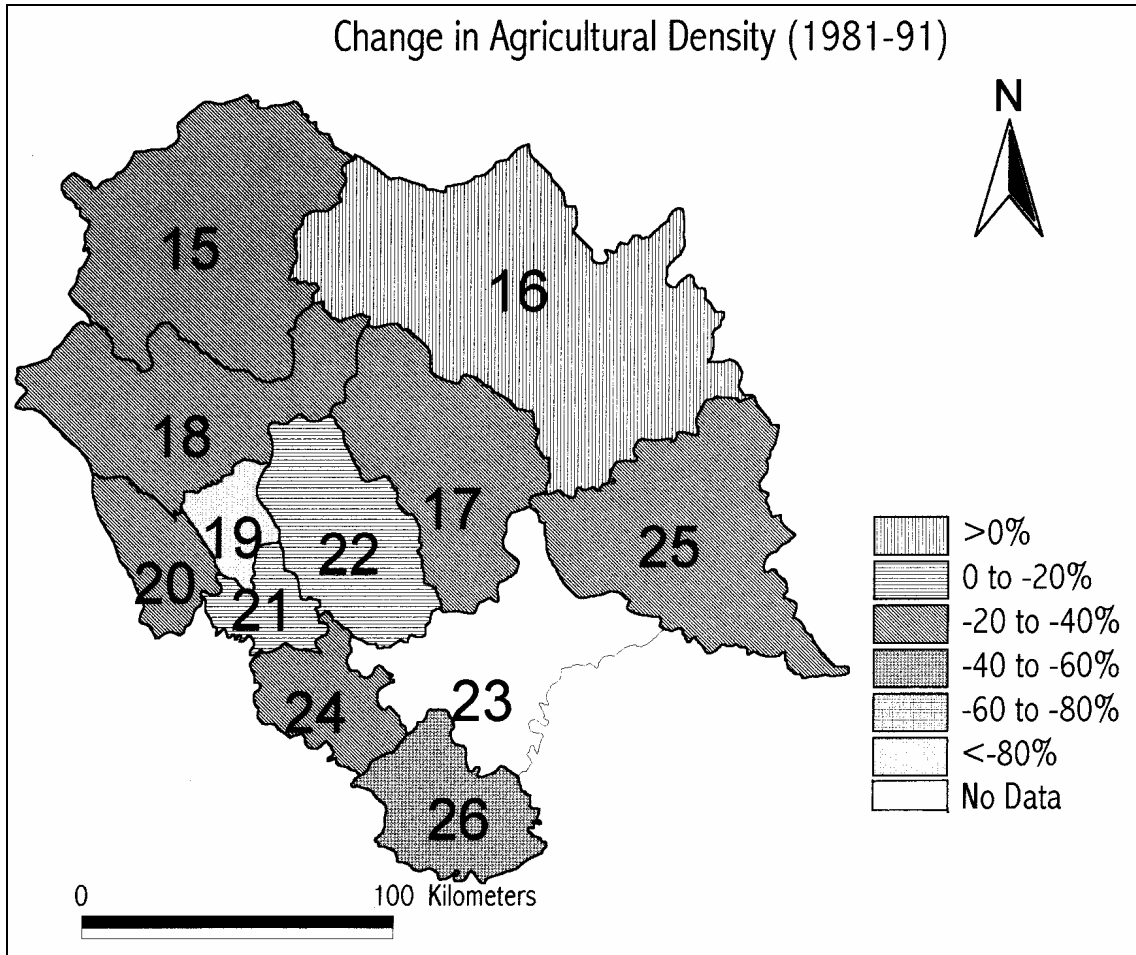


Figure 2. Percentage change in agricultural area per capita in 1991 over 1981. Except Lahul Spiti (code 16) all the districts exhibit a decreasing trend.

Table 6. Operational holding: districts are arranged according to descending order of % change in size of holding

Code - District	Area of holding (1991) in ha	% share to state	Average size of holding			% change (1971-91) in		
			1971	1981	1991	Area	Number	Size of holding
17 Kullu	45505	4.48	0.78	1.16	0.80	13.44	10.08	2.56
20 Una	96026	9.46	1.53	1.66	1.48	8.92	12.41	-3.27
26 Sirmaur	102178	10.07	2.43	2.72	2.33	28.80	34.67	-4.12
24 Solan	94993	9.36	2.26	2.31	2.03	9.53	21.88	-10.18
16 Lahul Spiti	6342	0.63	1.90	1.81	1.58	33.07	59.53	-16.84
15 Chamba	58556	5.77	1.11	1.07	0.91	8.06	31.79	-18.02
21 Bilaspur	53747	5.30	1.46	1.38	1.18	16.94	44.89	-19.18
23 Shimla	125746	12.39	1.78	1.94	1.40	11.90	41.94	-21.35
19 Hamirpur	77482	7.64	1.57	1.45	1.17	7.42	44.21	-25.48
22 Mandi	119564	11.78	1.22	1.31	0.90	1.80	37.82	-26.23
25 Kinnaur	13378	1.32	1.86	1.63	1.37	10.22	49.13	-26.34
18 Kangra	221125	21.79	1.62	1.32	1.01	1.66	63.61	-37.65
Himachal Pradesh	1014642	100.00	1.53	1.54	1.20	9.00	38.59	-21.57

Almost all the districts showing a decreasing size of operational holding (except Kullu) mainly due to the increasing number of holdings in respect to the area in last two decades (Figure 3). Kangra is the worst affected district, where the number of holding has increased more than 38 times than that of area.

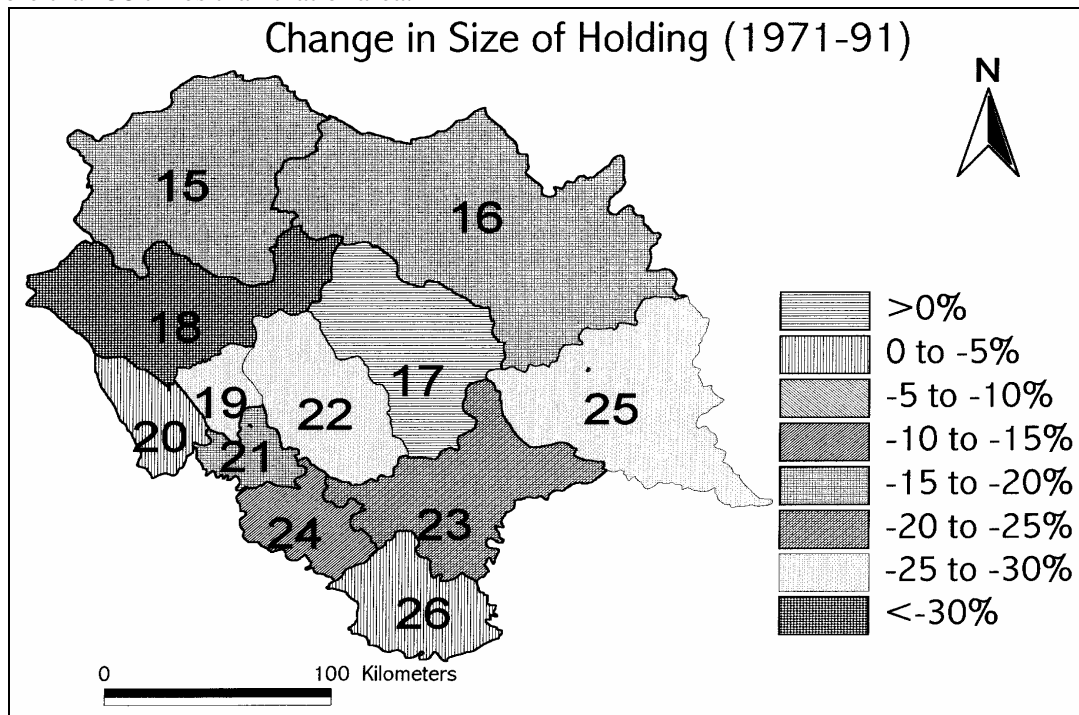


Figure 3. Percentage decrease in average size of holding (except Kullu, code 17) in the last two decade.

Table 7. Share of each social group of population and holding: districts are arranged in according to the distribution of land holding among social groups (finest to worst) based on the average of absolute deviation of size of holding by SC, ST, and Others

Code - District	Scheduled Caste			Scheduled Tribes			Others		
	% share of population	area of holding (in %)	average size of holding	% share of population	area of holding (in %)	average size of holding	% share of population	area of holding (in %)	average size of holding
24 Solan	31.27	21.7	0.69	0.64	0.4	0.63	68.09	77.9	1.14
26 Sirmaur	30.18	17.1	0.57	1.61	1.5	0.93	68.21	81.4	1.19
22 Mandi	28.98	18.5	0.64	1.21	1.6	1.32	69.81	79.9	1.14
23 Shimla	27.13	17.6	0.65	0.71	0.3	0.42	72.16	82.1	1.14
21 Bilaspur	25.82	14.4	0.56	2.70	3.3	1.22	71.48	82.3	1.15
17 Kullu	28.93	18.0	0.62	3.61	1.5	0.42	67.46	80.5	1.19
15 Chamba	19.75	8.3	0.42	28.35	26.9	0.95	51.90	64.8	1.25
16 Lahul Spiti	7.11	4.1	0.58	76.97	95.9	1.25	15.92	-	-
18 Kangra	21.17	8.7	0.41	0.14	-	-	78.69	91.3	1.16
19 Hamirpur	23.68	8.4	0.35	0.06	-	-	76.26	91.6	1.20
20 Una	22.46	7.4	0.33	0.01	-	-	77.53	92.6	1.19
25 Kinnaur	26.87	15.1	0.56	55.58	84.9	1.53	17.55	-	-
Himachal Pradesh	25.34	13.6	0.54	4.22	3.9	0.92	70.44	82.5	1.17

Almost all the districts exhibits a lion share of average size of holding by other than SC & ST population (except Lahul Spiti and Kinnaur, where they are minor group). In the case of SC population (which comprises more than 25% of total population of the state) the distribution of area is worst, sharing only 13.6% of the total occupied area.

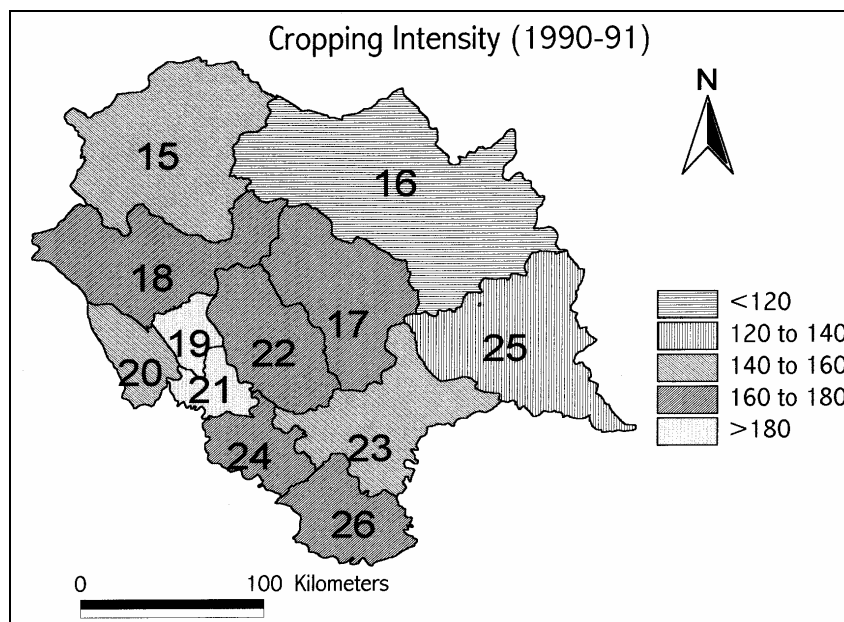


Figure 4. Cropping intensity

Table 8. Cropping intensity: districts are ranked according to the decreasing order exponential trend of cropping intensity

Code - District	Cropping intensity in different time frame				Exponential trend
	1968-69	1976-77	1983-84	1990-91	
21 Bilaspur	171.0	175.5	189.9	187.5	1.0049
24 Solan	146.9	158.2	148.1	164.7	1.0038
19 Hamirpur	180.5	178.6	192.7	189.8	1.0031
26 Sirmaur	169.0	177.2	178.1	180.0	1.0027
22 Mandi	162.7	166.1	170.7	171.9	1.0026
17 Kullu	153.0	156.2	155.0	161.2	1.0020
20 Una	159.2	162.2	172.3	159.2	1.0009
15 Chamba	155.1	154.7	151.8	156.6	1.0001
23 Shimla	147.9	154.0	150.8	144.6	0.9989
18 Kangra	177.3	185.8	167.4	176.0	0.9983
16 Lahul Spiti	107.1	108.5	104.2	103.9	0.9982
25 Kinnaur	135.7	135.2	132.7	120.8	0.9951
Himachal Pradesh	162.4	167.6	165.7	167.5	1.0011

The district of Bilaspur, Solan, Hamirpur, Sirmaur, Mandi, Kullu, Una, and Chamba exhibit a marginal increasing of cropping intensity, whereas Shimla, Kangra, Lahul Spiti, and Kinnaur exhibit a decreasing trend of cropping intensity. As a result, the state altogether do not exhibit any significant change in cropping intensity in the four time-series data recorded between the period 1969 and 1991.

The consequential changing landscape of Himachal Pradesh in last two decades is mainly due to the population growth. Though the population growth is a natural phenomena, and the statehood growth rate is below the national average (23.85% in 1981-91), but this rate is widely varied among Himachal districts. The decadal growth rate of Chamba, Kullu and Solan is higher than 25%, whereas the Lahul Spiti district has shown a negative growth rate in 1981-91. As a result the compound growth rate of net sown area and forest cover of Solan and Hamirpur has decreased significantly in last 25 years whereas the Lahul Spiti district has shown an increasing trend of net sown area as well as area under forest. Hamirpur is the worst affected district in terms of decreasing agricultural density per capita resulting an alarming increase of physiological density. This increase has overturned the primary sector only because of more than 90% population is engaged only in this sector. In contrast to this Lahul Spiti is the only district which has shown a significant decrease of physiological density in 1991 over 1981. Almost all the district has shown an decreasing trend in average size of holding during 1971-91, except Kullu, where the trend is marginally positive.

Except the above all environmental factor, there is widely uneven distribution of land holding among different social groups. The Scheduled Caste (SC) and Scheduled Tribes (ST) are the worst effected social group in the state in terms of occupied area. The SC and ST population of the state comprises about 30% of total population, holding only 17.5% of occupied area. As a result the average size of holding of other than SC/ST population is much higher than that of these minor groups of the state.