PLANNING FOR CLIMATE CHANGE, LOCALLY

A case Study from the Himalayan Mountains

Subrata Mandal

1. INTRODUCTION

The relation between mountains and climate is two ways. On the one hand mountains play a very important role in determining climate conditions and hydrological cycles of any continent or local region and on the other changes in climatic conditions is likely to have a deep and probably devastating impact on the mountain ecosystem due to its fragility. Planning for climate change therefore needs to be two pronged, it should be able to evolve mitigation strategies to prevent adverse climate conditions and also prepare to adapt itself in case of such an eventuality. The two most important factors that directly relate to climate change are land and energy use and hence should be the focus of planning exercise. A decrease in forest area would have an adverse impact on climate and hydrological cycle, both locally and globally. Increase in local forest area would have to be a primary goal to reduce adversities of climate change. With regard to energy use a switch over to non-conventional and renewable energy sources would reduce the severity of climate change.

Local land and energy use patterns are intricately linked to other issues like consumption habit of the population, lifestyle, level of development, institutional arrangements etc. To bring about an alteration in land and energy use therefore needs to address the entire gamut of development process in the mountains. One of the most important factors of the development process is the choice of technology. Adopting suitable technology for land and energy use can be an important aspect of local planning for climate change.

This article discusses the problem of sustainable development in the mountains of India, particularly in the Himalayan region, and presents a case study of land-use and energy planning in a micro-watershed to illustrate how land under forest can be enhanced and emission of greenhouse gas can be reduced by rational use of land and energy resources with choice of appropriate technology. The case study uses optimisation technique for the alternative static allocation of land resources and available technologies.

2. PROBLEMS OF SUSTAINABLE DEVELOPMENT IN MOUNTAINOUS AREAS

Mountain heights play a crucial role in the climatic conditions of the tropical region of India and determine the regional hydrological conditions. The glaciers and watersheds of the mountain regions have been the sources of innumerable water streams which form into rivers and major flows of surface water in the lower plains. The slopes of the hills have mostly been covered by forests which often contain a rich biodiversity of plants and animal organisms. Today, such forest eco-systems are very often fragile in many parts of the mountainous regions of India. The fragility has been due to the extremely leached and poorly developed soil conditions of the forest ecosystem (Rao and Saxena, 1994).

In India, the mountain regions with forest resources have been inhabited by human population in scattered settlements. In the early stages of development of the economy, the traditional societies in these settlements had evolved their livelihoods in tune with the ecological processes of the region. The pattern of land use, the cropping pattern in agriculture and other practices relating to primary activities in most of the tribal societies of the hills took account of nutrient recycling and soil conservation, e.g. by practicing crop rotation and leaving the plot fallow for some time (Ramakrishnan *et al.,* 2002).

With the growth of human population and livestock, there has been a change in the land-use pattern, forest land being converted into agricultural land or forest land being overused for animal grazing – both causing land degradation. The increasing dependence on rain-fed agriculture on slopes or terrace cultivation by removing forests to meet the increasing food requirement of a growing population has caused soil erosion in the hills. About 90% of the total cultivated area in the mid hills of the western Himalayas is under rain-fed agriculture (Bhatnagar and Kundu, 1992). The model based exercises try to identify technology that will reduce land under rain-fed agriculture and allow its conversion to a more sustainable use which can halt the process of soil erosion.

Cattle, goats and sheep in the western and central Himalayas and pigs and poultry in the eastern Himalayas constitute important livestock wealth, while yaks are reared in Alpine areas. Land holdings being very small, livestock supplement the income of poor households and are considered as constituting a capital asset. Animal dung is used as fertilizer. The energy requirement for land preparation and transportation in agriculture is entirely met from bullock power. Whilst the high utility of livestock has led to an increase in its population, this has led to overgrazing due to lack of exclusive fodder crop farming in the mountains. Mismanagement of forests contributes to overgrazing and forest degradation (Singh *et al*., 1994). The reserved forests are managed by the forest department mainly to earn revenue. Gradually these forests have been converted into *chir* pine and *deodar* forests which have high commercial value; broad-leafed species like *oak*, *kafal, sandan, bauhinia, ficus and hatab,* which supplied fodder and fuel-wood, have gradually dwindled. The pressure for fuel-wood and fodder consequently fell on the civil and community forests, which started shrinking. Efforts to diffuse grazing pressure on land in local animal husbandry systems do exist. The animals are sent to high altitudes for grazing in the summer months and a significant portion of fodder is obtained from crop residue (Rao and Saxena, 1994). Nevertheless, a trend of increasing pressure of livestock on forests is obvious. The optimisation model of land use that is outlined in the following section takes into account the fodder requirement and the possibility of animal energy utilization for economic activities.

Energy is demanded in the hills for cooking, lighting and heating in the household. The possibility of irrigated cultivation of fruit trees, herbs and medicinal plant and vegetables may be considered in small areas of land if electricity is available for such activities. It is estimated that about 1.1 trillion cubic metres of water flow every year down the Himalayas. The use of hydro-electricity for household purposes would reduce the pressure on forests for fuel-wood. Decentralized and small-scale management of micro- hydro-electric power systems, involving people participation and adapted to mountain constraints, appear more suitable, particularly for meeting the energy needs of marginal areas. The Himalayas offer a potential of generating 28,000 megawatt of electricity (Saxena *et al.*, 1994).

Technological options for the supply of energy for agriculture and household needs have to be assessed and explored. Fuel options which are economically efficient and ecologically sound need to be identified. Energy options with least intensity of carbon-dioxide emission would be suitable for fragile mountain ecosystems. In the model, several fuel options for energy use in irrigation, cooking, heating and lighting have been considered. In particular, the impact of a micro-hydro-electric power system on land use has been estimated.

With deforestation, unsustainable agriculture and their consequent impact on soil, water, vegetation cover and biodiversity, the carrying capacity of the mountain ecosystems for the human and livestock populations has declined over time. With a growing population, the development of ecological degradation has often led to out-migration of able-bodied males of working age to the plains for earning a livelihood and sending remittances back to the hills. In many places, as indicated by some of the primary surveys, this creates populations dominated by dependents consisting of the old and the children who are being looked after by the adult women staying back in the villages. Most of agriculture for growing food and collecting fuel wood and water, which is all quite physically strenuous, is being carried out by the women. This adds a gender dimension to the pattern of livelihood and quality of life in the hills and raises concern for the well-being of the women due to stress caused by dwindling life support as provided by the ecosystem.

3. A CASE STUDY OF OPTIMAL LAND AND ENERGY USE

The discussion in the preceding section points to the importance of land-use patterns in determining both ecological sustainability of an ecosystem and the economic well-being of the people inhabiting the region. We submit below an optimisation model of land use for the Hawalbag watershed region and summarize the results in the next section in order to illustrate the real extent of conflict between developmental needs and environmental concerns. The analysis based on the model essentially focuses on the existing patterns of land use and its connectivity with various economic activities in the watershed and compares it with the optimal pattern of land use for the region. The comparison points to the potential of combining efficient choice of technology and land use with environmental conservation in similar watershed regions in the mountains. It illustrates how sometimes inefficient land-use and technological choice in the hills cause both loss of conventional economic value as well as ecological resources like top soil, air quality, *et cetera.*
The optimisation (linear programming) model articulates the choices in the use of land, technology and natural resources for alternative purposes with the objective of net revenue maximization from the major primary activities of the watershed economy, subject to meeting the basic need for food and energy by human beings as well as fodder for livestock, the latter being an important resource providing support to the mountain economic system. A linear programming framework has been chosen for the model primarily for its capacity to elegantly map intricate interrelationships among a large number of variables in a systematic manner. Such a framework provides the scope for optimising an objective function subject to a large number of constraints expressed as demand-supply equations.

The objective function estimates the value of returns from all land-use activities which include agricultural output (foodgrains and vegetables), fodder from pastures and forest products. The cost items include cost of cultivation of foodgrains and vegetables in agricultural land, fodder in pasture land, forest products in forest land and cost of conversion of land from one use to the other. It also includes the cost of household energy use for cooking, heating and lighting. The revenue from output of each of these land-use activities is valued at current market price. The cost computations of the inputs are discussed below in detail.

The total requirement of each input and its aggregate supply from various sources is specified in the form of demand-supply equations. The coefficients express input demand for a unit of output and the unit cost of supply from available sources respectively. Additionally, there are upper bounds to input availability in the case of limited supply.

The lower bound for food, fodder and energy requirement is specified for the entire human and livestock population of the watershed. These requirements are based on the primary survey and take into account the food habit of the population. Agricultural land allocation has to be done in a manner such that the organization of crop production activities in different seasons and in different types of land can meet the basic food requirement determined by the consumption pattern of a given population. The allocation of pasture land has to ensure fodder for a given size of livestock. The possibility of obtaining fodder from agricultural land in the form of agricultural residues and forest land in the form of leaf and grass has been allowed.

The surplus land that remains after meeting the basic needs of the watershed is devoted to the most market value adding use among the various options. The model considers the bounds of the availability of total land and water resources as given. To be more precise, the range of options that the model attempts to articulate in the case study covers: (1) the *use of land*, (2) the *choice of technology* and (3) *choice of fuel source*. This is discussed below in more detail.

The *use of land* can be either: agriculture with or without irrigation, pasture and forestry after allowing for conversion from one use to the other. Choice of cropping pattern along with seasonality has been explicitly considered in the model. In the current situation, only 40 acres can be irrigated from natural streams. The cost of an irrigation network has been simulated into the modelling structure that would allow for irrigated cultivation of around 400 to 425 acres depending on water availability and cropping pattern. The irrigation network would consist of pump sets and engines that would lift the water from the river bed to a height from where water can be canalized to agricultural land. Electricity required for pumping water would be supplied from the micro-hydro-electric plant which can be located on the main river of the watershed. The other options considered for the supply of energy for irrigation are biogas, diesel and animal power (lift irrigation). The cost coefficient of irrigation per acre of different crops have been computed by taking into account annualized capital cost, operational cost, end use cost and the amount of water required per acre of cultivation of different crops. The amount of area cultivated in the two seasons would vary due to seasonal variation in water availability and water requirements of cultivated crops. The total requirement and options for supply of other inputs in rain-fed and irrigated agriculture are discussed below. The cost coefficient per unit (acre) of pasture land takes into account the cost of seeds, fodder plants and labour required for growing and maintaining the pasture. The cost coefficient of forest land takes into account the conventional cost items of raising forests. The input requirement for a given productivity has been expressed as fixed coefficients for different categories of land use. The model has been designed to take into account cost of land conversion from present land-use pattern to an alternate use. This would indicate the average investment requirement for an alternate pattern of land use.

The *choice of technology* is determined by the use of (a) seed, (b) water, (c) organic and chemical fertilizer, (d) animal energy for land preparation and grain transportation, and (e) human labour. The requirement of each of these inputs is expressed as coefficients associated with the land type (rain-fed and irrigated) allocated for cultivation of foodgrains and vegetables in the monsoon (*kharif*) and winter (*rabi*) seasons. The requirement of nitrogen (N), potassium (K) and phosphorus (P) has to be met from chemical and organic fertilizers. The availability of organic fertilizer is associated with the dung produced by the livestock population and slurry from biogas digester. The seasonal nature of demand for animal labour in different crop producing activities in overlapping time has been synchronized such that the given draught animal population can be engaged optimally. The economic cost of all the agricultural inputs has been calculated. The cost of fertilizer has been calculated net of taxes and subsidies. The cost of animal and human labour, owned and hired, is valued at the prevailing market wage rate. The limit to supply of human labour has been determined by the available working population in the watershed.

The *choice of fuel sources*, as being either commercial or non-commercial, and their relation with food, fodder, fertilizer and land-use pattern is included in the model. For example, crop waste from agriculture can be used either as fodder or biomass fuel or compost fertilizer. Biomass crop waste fuel is a substitute of commercial and non-commercial energy forms. Dung from livestock can be used alternatively for fertilizer or energy used for household activities; livestock also provides energy for agriculture and rural transportation. The range of choices for household cooking energy includes animal dung, crop residue, fuel-wood, biogas, kerosene, liquid petroleum gas (LPG), electricity and coal; for lighting energy, it includes kerosene, electricity and biogas; and for space heating, it includes animal dung, fuel-wood, electricity and coal. Energy inputs like biogas and micro-hydro-electric power have been included among the options to understand their economic viability as a locally available non-conventional and renewable energy option in the context of development in the remote mountain regions. The total availability of human excreta has been considered as an input to biogas plants; the choice of use of animal dung as input in the digester has also been allowed. For cooking and lighting energy options, economic cost per unit (joules) of useful energy has been considered by taking into account the efficiency of the end-use device, including end-use cost (NCAER, 1978; TERI, 1989). For non-traded inputs like animal dung, crop waste and fuel-wood, the labour cost of time spent in collecting these inputs has been considered. The demand for cooking, lighting and space heating has been obtained from primary survey of household energy demand in the watershed.

The analysis also addresses some ecological implications of the optimal land-use choice: (a) emissions in the form of carbon dioxide from agricultural processes and household energy use, and (b) soil erosion. Total emission of carbon is determined by the choice of fuel in cooking, heating and energy use in agriculture. The emission coefficients for each of the fuel sources used in the energy using activities have been obtained from secondary sources (NCAER, 1978;TERI, 1991). Electricity from the micro-hydro-electric plant does not cause any emission. The net emission takes into account carbon sequestered in the process of growing forests. The rate of carbon sequestered per acre of forest in the Himalayan mountains has been obtained from secondary sources (Houghton. R.A. 1996**;** Lea, Zhou, Jung and Sathaye 1996**).** The rate of soil erosion has been calculated by using the universal soil loss equation (Wischmeier and Smith, 1978). It takes into account coefficient of erosion due to rainfall and soil quality, length and slope of land in different land-use activities, and management and erosion control practices like erecting bunds and terraced farming. Broad categories of land-use activities, i.e. rain-fed and irrigated agriculture, pasture and forests have been considered to calculate the total amount of annual soil loss. Erosion coefficients of four ranges of slopes, i.e. 0 to 5 degrees, 5 to 10 degrees, 10 to 45 degrees and above 45 degrees have been obtained for each of the above categories of land use. All coefficients used in the calculation of soil loss have been obtained from Watershed Management Directorate of the province.

The chosen area for the study is the Hawalbag watershed, located on the bank of river Kosi, in Almora district of Uttaranchal province – is in the central Himalayas between altitude 1,000-2,000 metres, where human activities have been widespread in terms of population growth, deforestation, extension of agriculture on mountain slopes, growth of livestock and demand for energy resources. The area spreads over 6,088 acres and contains a human population of 4,780 and a livestock population of 3,729 distributed in 15 villages. Details of the land-use pattern are given in Table -1.

The model has been estimated on the basis of data obtained from primary survey sources conducted in the Hawalbag area and supplemented by the geographical information system database on land use recorded on a scale of 1:50,000 for Almora district of the Forest Research Institute, Dehra Dun. The exogenous variables of the model describe the basic needs of the people in the concerned watershed region for a given year. The estimated model considers the economy of the watershed region to be representative for illustrative purposes.

4. RESULTS OF THE MODEL

The major feature of the results of the model has been that out of 6,088 acres of land use, the area for agriculture with irrigation and rain-fed agriculture should be 410 acres and 21 acres respectively, as against 40 acres of existing net sown irrigated area and 2,740 acres of net sown rain-fed agriculture (Tables.1). The land under pasture should also decrease from the existing 1,371 acres of use to 927 acres. The forest land under use should increase from the existing 1,533 acres to 4,451 acres of land. Cultivable wasteland and land under trees and shrubs would also be converted to forest land. Uncultivable wasteland and land under non-agricultural use, which is used for residential buildings, schools, hospitals, post offices, *et cetera* has not been considered for land conversion.

Table -1. Current and simulated, optimal land-use areas [acres] in the Hawalbag micro watershed

Land-use type	Current area	Optimal area
Net sown area (irrigated)	40	410
Net sown area (rain-fed)	2,740	21
Pasture land	1,371	927
Forest land	1,533	4,451
Non-agriculture uses	273	273
Cultivable waste land	18	-
Uncultivable waste land	6	6
Fallow land	-	-
Shrubs and trees	107	-
Total land	6,088	6,088

The implication of land conversion from present land use to the simulated optimal land use is given in Table 2.

Table 2. Land conversions following the optimisation analysis.

Land conversion	Area [acres]
Rain-fed to irrigated agricultural land	370
Rain-fed agricultural land to forest land	2,349
Pasture land to forest land	444
Cultivable waste land to forest land	18
Land under trees and shrubs to forest land	107

The results of crop production activities associated with the agricultural land type (rain-fed and irrigated) allocated for cultivation of foodgrains and vegetables in the *kharif* and *rabi* seasons in the simulated optimal land use which would meet the basic requirement of foodgrains and vegetables of the population of the watershed are summarized in Table 3.

Table 3. Optimal land allocation for agriculture

Land type	Seasons	Crops	Land requirement (acres)
Irrigated	Kharif	Rice	253
Irrigated	Kharif	Vegetable	61
Irrigated	Rabi	Wheat	318
Irrigated	Rabi	Vegetable	26
Irrigated	Rabi	Mustard	12
Irrigated	Rabi	Potato	52
Rain-fed	Kharif	Rice	10
Rain-fed	Kharif	Madua	10
Rain-fed	Rabi	Wheat	10
Rain-fed	Rabi	Potato	10
Rain-fed	Rabi	Mustard	-

The optimisation results emphasize the economisation of land use under agriculture by shifting acreage from inefficient rain-fed agriculture on slopes to irrigated agriculture with the use of inorganic fertilizer or organic manure in valleys as far as possible. The use of pasture land should also be kept at the minimum by efficient resource use and all surplus land, after meeting the need of food and fodder, should be transferred for use in forestry. It is the net added value of forestry products which makes forestry an attractive option purely on economic grounds.

Even without taking account the ecological value of forests, the revenue maximization objective would warrant the transfer of land from agricultural and pastoral use to forest, subject to the constraints of meeting the basic needs of food and fodder within the watershed. The simulated decline in the agricultural area essentially reflects the assumed economic inefficiency of rain-fed agriculture.

The implication of further growth of population with respect to food demand has been worked out. An increase in food demand by 1% would require agricultural land to grow by 1.85%. Given the capacity of irrigation infrastructure, the required increase for agricultural land would have to be met from extension of agriculture to rain-fed land. Thus, increase in demand for food would put pressure on pasture land and forest land which would be set to decline gradually.

With respect to water, the results of the model indicate that its availability for irrigation is a key factor that influences allocation of land for different uses. Due to the lack of irrigation facilities, the potential of water is not fully realized now. The maximum potential of sustainable water use permits 410 acres of irrigation. The optimal land-use pattern makes full use of the irrigation potential for production of foodgrains and vegetables, making the water constraint binding and requiring small acreage of land use under rain-fed conditions. An installed capacity of 20 kilowatt hydro-electric plant and six engines of 20 hp will be required to pump water to a height of 165 feet from where the water can be canalized to irrigate the required amount of land. The adoption of this technology would considerably reduce land use under rain-fed conditions.

The results of the model indicate that there is sufficient scope for increasing productivity in agriculture by better management of local resources like dung and other biomass-based manure. A technological intervention for anaerobic digestion of dung would greatly increase the fertility potential of locally available organic manure. About 43% of the dung generated will optimally flow to the anaerobic digester to meet the entire requirement for N, P and K of the watershed. Further, the anaerobic technology will initiate substitution away from chemical fertilizer which would make agriculture better environmentally sustainable.

On the livestock management, the optimisation of net revenue points to crop residue, fodder grown in agricultural lands (when it is left fallow between seasons) and grazing in pasture and old forests as the major sources of fodder. Crop residue can contribute 2,059 tons (22% of total fodder requirement). Fodder from agricultural land contributes marginally, i.e. 0.11% of total fodder requirement. The major share of fodder comes from grazing pasture. In this particular exercise, it has been assumed that the livestock does not graze in the new forest area since allowing grazing while regenerating of forests will decrease the chances of survival of the plants. Grazing may be allowed in a full-grown forest. About 2,556 acres of forest will be required to sustain the livestock population if grazing in full-grown forests is allowed; in that case, no pasture land would be required. So, as forests start regenerating, pasture land may be gradually transformed into forest. The implication of increase in livestock population has been worked out, indicating that a 1% increase in fodder demand would increase allocations to pasture land by 1.28%. The results show that it is better to use crop residue for fodder than for other uses like compost fertilizer or for cooking fuel.

The energy requirement for land preparation and local transportation of foodgrains and vegetables can be met from the available animal energy in both seasons of cultivation. According to the results of the model, 80 and 5% of animal energy available from draught animals will be utilized in irrigated and rainfed cultivation respectively in the *kharif* season. In the *rabi* season 87 and 5% of the available animal energy in irrigated and rainfed cultivation will be utilized. For local transportation 35% of the available animal energy will be utilized in irrigated cultivation in the *kharif* season and less than one percent will be used in rain-fed cultivation. In the *rabi* season 70% of the available energy will be utilised in irrigated and 2% will be utilised in the rain-fed cultivation. Thus animal energy availability will be sufficient for land preparation and agricultural transportation in the watershed.

The requirement for inanimate energy for cooking, lighting and space heating should be ideally supplied, as shown by the results of the model, by electricity from micro-hydro-electric units which can be set up to tap the hydro-energy potential of the region. An installed capacity of 385 kilowatt will be sufficient to supply the required amount of cooking energy for the entire watershed. For the purpose of light energy, an installed capacity of 380 kilowatt will be sufficient and for space heating in the cold mountain region an installed capacity of 360 kilowatt will be required. In any situation of scarcity of electric power because of inadequate investment to utilize such potential, it is the LPG gas and soft coke which would be the next best option for cost economisation for cooking and space heating respectively. Dung is to be mainly used for organic fertilizer. The optimisation model warrants a part of it to be used in an anaerobic digester to produce slurry for fertilizer. Biogas turns out to be uneconomical due to low productivity in cold mountain regions.

The environmental impact of the change in land use and related activity pattern as per the net revenue optimisation model would be favorable in respect of top soil loss, carbon emission and carbon sequestration. In the present land-use pattern, the extent of soil erosion works out to 8,709 tons; according to the simulated land-use pattern, the soil loss works out to 2,003 tons, thus, total soil erosion will be reduced by 77%. A large amount of agricultural land located on the slopes can be released for afforestation by increasing the area under cultivation in the valley land. The carbon emission due to energy consumption would also be drastically reduced by the utilization the hydro-potential of the region. This would require, of course, the mobilization of a capital fund and institutional arrangements for the implementation of small power projects.

Finally, transfer of land to forest use will facilitate substantial carbon sequestration in the region by substantive amount, the net sequestered amount being 5,466 tons of carbon as per the optimal solution. Afforestation would also have favorable impact on the employment situation due to expansion of forestry-based activities. However, such land-use change in favour of forests would also demand appropriate institutional arrangement to be in place.

5. CONCLUSION

In the light of the case study referred to above, it is important to note that environmental conservation of resources is intimately linked with the pattern of land use and technology in the mountains. It is also interesting to note that profit or net revenue maximizing allocation of resources in terms of land use goes often along with environmental conservation of resources like top soil, water resources and other factors that prevent adverse climate change. It is, in fact, the choice of land use along with associated economic activities in the hills which is the crucial factor in characterizing the developmental process in the mountains.

The optimisation results show that an economically viable and ecologically sustainable pattern of resource use in the mountains is possible that can provide the required food, energy and fodder and can, simultaneously, reduce the process of degradation by controlling soil erosion to a large extent. This pattern will also improve air quality and reduce the possibility of global warming through carbon sequestration by increasing area under forests and can be an effective strategy for prevention of drastic change in climate. The optimal land- and energy-use pattern is not driven by self-perpetuating economic considerations due to the perception of food security of poor people living in far flung mountain areas. Food shortages in such areas can be conspicuous during times of landslides and natural disaster that keep the area and supply lines cut off for long periods. In general, poor people in many regions are driven by concerns of food security. Hence, they would ensure that the land they possess should guarantee availability of foodgrains and fodder to the extent possible. The perception about food security can change with the process of development of the region and economic well-being of the population. Lack of capital and technological know-how also prevent communities of such regions to adopt a land- and energy-use pattern as outlined in the case study above. Such problems can be addressed by transferring funds to the village local governments from the federal governments in the course of democratizing the development process. Assigning carbon credit, as envisaged in the Kyoto Protocol may also contribute to solving the problem of capital crunch.

In terms of a sectoral strategy of development, the case study suggests that forestry and livestock raising mainly for livelihood will be economically beneficial and ecologically sustainable in the hills. Agriculture should be confined mainly to the valleys, except for such plantations which can be grown on gradients without degradation of the soil-water system. This would not necessarily cause a deficit of foodgrains. However, if there is deficit in some cereals, pulses *et cetera*, in the mountains, it needs to be imported from the plains. While the mountains provide ecological support to the plains through the major flows of surface water and forest resources, the plains need to supply, in return, foodgrains in which there is a deficit and other industrial goods to ensure life support on the hills.

What is important is both efficient choice of technology from the overall point of view of resource economisation as well as careful consideration of environmental or ecological costs and benefits in addition to the conventional ones.

The analysis of environment related problems in any region should take account not only of the limits of nature in decisions of economic choice, but should also analyse the impact of economic choices on climate change and ecology and take account of the feedback effect of ecological changes on the economic system to understand the dynamics of long-run processes of economy, society and the nature.

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