Introduction

Land use is a synthesis of physical, chemical, and biological systems and processes on the one hand and human/societal processes and behaviour on the other. The monitoring of such systems includes the diagnosis and prognosis of land use changes in a holistic manner at various levels. Land use change may be examined by considering conversion of forest to crop and rangeland; losses of productive land through various factors; conversion of wetlands to agriculture and urban use; and conversion of other types of land to various human uses. The per capita availability of land in India decreased from 0.9 ha in 1951 to 0.5 ha in 1980-81. The situation of cultivated land is even more critical. The per capita availability of such land has declined from 0.48 ha in 1951 to 0.20 ha in 1981. This is likely to decrease further to 0.15 ha by 2000 AD. About 85 million ha of agricultural land and 37 million ha of forest lands are degraded to varying degrees out of the total land of 143 million ha and 67 million ha respectively (NLUCB, 1988). In recent years, various sustainable land use initiatives are being taken at national and global level under the Tropical Forestry Action Plan, World Food Programme, and UNCED-initiated a Forest Principles and Agenda 21. The Government of India initiated an agroforestry programme as an integrated sustainable land use management system. On 2 June 1992, it announced the National Conservation Plan in order to tackle such multidimensional problems facing the nation today.

Agriculture has undergone drastic changes from the mid-1960s through the introduction and application of various newly developed techniques in agrosciences such as crop and water management practices. Emphasis has been given to the integrated systems approach in crop production.

It is essential to plan and implement rational policies to minimize the regional imbalances of agricultural production. The present growth in crop production has to be sustained considering ecological and economic factors. The existing as well as emerging frontiers must be examined to enhance agricultural growth on a sustainable basis. The understanding of agroclimatic relationship through crop-weather conditions, soil fertility, water use efficiency, rain water management, and appropriate cropping patterns based on regional resource potential must be emphasized. Moreover, agroforestry, integrated crop management, biotechnology, and use of renewable energy must be emphasized for use in environmentally harmonious agriculture. Training of farmers has to be adapted to the changing technological environment.

The forest affects soil and water in many ways. Leaves and branches decrease wind strength, alter the absorption of solar radiation, and increase the surface area for evaporation. The root growth and the decomposition of plant organic matter, by soil fauna and microbes, modify soil texture and structure, affecting water penetration and drainage. Changes in vegetation cover can therefore have a significant influence on the hydrological cycle and climatic system (IGBP, 1992).

The study area consists of the states of Punjab, Haryana, Himachal Pradesh, and Jammu & Kashmir. On the basis of physiography and soil resources, this zone is clearly divisible into two sub-zones: the plains of Punjab and Haryana and the highlands. Based on altitude, soil types, geology, and rainfall, each of these two sub-zones may be further subdivided. Major
sources of water in the region, in addition to rainfall and river, are lakes, the ice caps of
glaciers, and underground springs. Underground water is largely concentrated in the plains of
Punjab and Haryana. The region covers a varied land use, from highly intensive monocultures
through rotational and intercropping to grazed rangeland and near-natural forests.

**Land Use Change**

Our analysis of land use for the last 40 years in the four states suggests that Punjab and
Haryana have reached the absolute limit of expansion of area under cultivation with almost
84% of the area being cultivated. Six to 8% of the area in these states is under urban uses.
Another 5% are under forests (mainly strip forests), and the remaining 2-3% is roads, canals,
and other infrastructural and industrial uses. Cultivable waste as a category has virtually
disappeared in these two states. Such intensive land use for agriculture is sustainable only
with increasing and continued high doses of balanced nutrients and other inputs such as
chemical fertilizers and insecticides. The proportion of area available for cultivation in
Himachal Pradesh and Jammu & Kashmir because of topography and physiography is rather
small and cannot be expanded without major private and public investments that in return will
result in major ecological problems and should be avoided.

The cropping pattern in the region has undergone a substantial change, with wheat and rice
emerging as a major crop rotation in Punjab and half of Haryana. Its expansion in Himachal
Pradesh and Jammu & Kashmir has been moderate. Crops that have been replaced by wheat
and rice, are gram, bajra, barley, millets and pulses. Area under cotton has grown in Haryana.
In absence of expansion of the sugar industry, the area under sugarcane has remained static.
The cropping pattern of the region has unnecessarily become energy-intensive and is
affecting the static balance of the underground water resources in the plains of Punjab and
Haryana. The growth of infrastructure, irrigation, and other technological factors are
responsible for a major shift in cropping pattern in favour of wheat and rice in the states of
Punjab and Haryana.

A number of policy steps must be taken to encourage farmers to switch from rice, which is a
water and fertilizer-intensive crop in the region, to crops that demand less water. This can be
achieved through price policy, research and development efforts, and establishment of
agroprocessing industries so as to make sustainable alternatives more attractive to the
individual farmers. Without supplementary organic manure, intensive agriculture leads to
depletion of soil fertility. Ludhiana district in the green revolution State of Punjab, which
records the highest yields of many crops, now also records the highest deficiencies of plant
micronutrients. Extensive use of organic manure is the only way to overcome the deficiency.
In Punjab, above 5 million tonnes of rice straw is being burnt every year during October to
December. If crop residues were ploughed back into the soil, the rate of micronutrient
depletion would be substantially reduced (CSE, 1982).

Since 1965, when water from the Bhakra canal was brought to the farm, the rise of the water
table has also been a serious phenomenon. Since 1985, the rate of rise in the water table has
been above 1 m annually. Patches of salinity have started appearing at the farm level. The
situation is worse in higher rainfall areas where waterlogging follows shortly after the rains.
Apart from affecting agricultural crops, a high water table causes floods even during slight
rains because of the reduced moisture storage capacity of the soil. In Hissar, the bearing
strength of the soil has declined to less than 50 % in 50 years (Chaudhri et al., 1991).

**Diversification of Agriculture**

A diversification of agriculture to increase the area under oilseeds and pulses should be
encouraged. Sunflower is becoming a prominent crop among the oilseeds. Its water
requirement is quite high. Although the sugarcane area has been substantially increased, it
has not reduced pressure on ground water. The ground water position has been distributed
by a tremendous increase in food production, especially wheat and rice (119.2 lakh tonnes in
The ravinous and undulating areas of Khandi tract can also be developed for horticulture, which will reduce spending on reclamation. The development of land first for agriculture and then its conversion for horticulture is not the appropriate method. Horticulture requires less water than an intensive cropping system.

More area is brought under cotton because its returns per hectare can compete with those from paddy. Crop rotation, which is a fertilizing process, should be promoted in a holistic manner. About 7 to 8% area should be cultivated under fruit trees and marketing facilities provided.

**Potential for Diversification of Agriculture**

The economics of Jammu & Kashmir and Himachal Pradesh have large forestry and horticulture sub-sectors. Forest area and forestry development area in both these states is substantial. The growth of different types of forests during the last two decades has been uneven. The area under forests in Punjab and Haryana is less than 5% but is slowly growing. There is not much scope for growth of block forests in these states. Most of the growth has been in strip forests on the banks of canals.

Despite major data problems for a temporal analysis of forest cover in the study area, we found that as per official records, 33% geographical area of Himachal Pradesh, 9.9% of Jammu & Kashmir, 5.6% of Punjab, and 3.8% of Haryana were under forest cover in 1986-87. On per capita basis the lowest forest cover is in Haryana and the highest in Himachal Pradesh. In absolute terms total tree cover is 20,880 sq. km in Jammu & Kashmir, 12882 sq. km in Himachal Pradesh, 776 sq. km in Punjab, and 644 sq. km in Haryana. The regeneration of forest for Himachal Pradesh and Jammu & Kashmir has been observed and needs to be monitored more carefully. A study of various forest types in combination with horticultural, pastoral, and other systems suggests that there is a wide variation in expected returns per year per hectare, which seem to be more attractive than those from crop husbandry provided marketing is taken care of.

Establishment of agroforest processing is required on a regional basis rather than on a state basis. The problem of marketing forest products, particularly wood in the absence of such industries within the region discourages individual producers from undertaking this activity.

**Integration of Horticulture with Agriculture**

Area under horticulture in all the four states has been growing rapidly since 1970-71 with fastest growth in Himachal Pradesh. The economics of Himachal Pradesh and Jammu & Kashmir have a significant horticulture sub-sector that is growing and emerging as a major component of the agricultural and agroprocessing facilities are some of the important problems of this sector.

Himachal Pradesh and Jammu & Kashmir are considered the fruit baskets of the region because of favourable climate and topography. In Punjab and Haryana, area under horticulture is small (less than 1%) but increasing. Some illustrative measures of rates of returns from horticulture suggest returns from ranging from 30 to 40 %. However, the experience of marketing, particularly of apple, suggests that expanding wood demand for packing of fruits is creating serious stress on the forests, especially silver fir and spruce. This has already been noted by the Government of Himachal Pradesh and Jammu & Kashmir. Subsidized cardboard boxes are being experimented with.

In view of the climate and the rugged terrain, fruit production is the only highly profitable enterprise where crop growing is not of much utility. Moreover, horticulture enhances the cohesiveness of the soil, preventing soil erosion.

With increase in demand for fruits, the National Commission on Agriculture has indicated that production must increase. Farmers ought, therefore, to be induced to grow more fruit trees.
Induction of farmers is possible, once a complete understanding of soil economics is arrived at.

The following possibilities are favourable to horticultural activities in the zone:

i. Agroclimatic and topographic conditions favour horticulture as an excellent source of income per unit of land area.

ii. Horticulture helps in using the land more efficiently than crops and conserving the soil, which is highly susceptible to erosion in case of cultivation.

iii. Horticulture permits the maximum use of natural resources by adopting the negative propagation.

The actual impact of horticulture on environment is increased by the need for packing cases. The use of wood for packing fruits has greatly increased the burden on the forest wealth, leading to extensive deforestation (Singh, 1992).

The standard boxes for packing apple can contain 9 to 18 kg. However, 1 t of the fruit is supposed to be contained in 55 standard boxes. Apart from the wood required to manufacture the boxes, 25% is further wasted on manufacture of logs and billets, 10% on sawdust, 15% on cut off rejection. Thus, one-third of the standing volume is wasted. About 65 packing cases of standard size are obtained from 1 cu m of the silver fir and spruce forest. The trend indicates that annually 10.8 km² of forest is lost while 6 km² is planted, i.e., about 3000 trees are lost. While the nursery stock takes about 5 years to be raised, a tree must grow about 100 to 120 years before it can exploited. The result is deforestation. Deforestation in turn leads to land degradation and soil erosion. To curb the problem and have an economically feasible and environmentally sizes of packing cases, use other materials for packing, and use wood in other forms.

The Himalaya is now under tremendous transformation that is accelerated with enormous speed. Most of the original lush green natural vegetation is presently replaced by shrubs, savannas, grass accompanied by gullies, ravines, and eroded and scraped landscape. The major use of forests presently is to meet the demand for industrial wood, which is needed in a great quantity, a large part of which is used for packing horticultural products.

Native plant cover normally provides good erosion control, hence sustenance of natural resource base for economic growth and development compatible with environment. Problems arise, though, when an area is deforested and converted into cropland, increasing soil erosion. The resulting soil loss reduces soil productivity and modifies the environment.

**Agriculture and Forestry: Coexistence and Complementarity**

Agriculture and forestry should be developed in an integrated way in the form of farm forestry and agroforestry under which crop productivity and fertility of soil and environment improve. The two sectors are ecologically and economically inseparable. A study of forest and agriculture indicates major difference (Table 1). However, the ecosystem approach and the crop management approach are complementary, yielding more productive agroforestry systems derived by farmers and rural people. It is desirable to grow two or more species together, a combination of species can be complementary. This is the basis of silviculture systems where crops are grown with commercial species for intercropping potential on rotation basis.
Table 1:

Comparison of characteristics of forestry and agriculture

<table>
<thead>
<tr>
<th>Forest characteristics</th>
<th>Agriculture Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perennial woody plants</td>
<td>Annual or oriental plants</td>
</tr>
<tr>
<td>Focus on vegetation</td>
<td>Focus on reproductive</td>
</tr>
<tr>
<td>growth</td>
<td>growth</td>
</tr>
<tr>
<td>Thousands of species</td>
<td>Tens or hundreds of species</td>
</tr>
<tr>
<td>Mixed culture</td>
<td>Monoculture frequent</td>
</tr>
<tr>
<td>frequent</td>
<td>Single or few production</td>
</tr>
<tr>
<td>Multiple products and</td>
<td>goals</td>
</tr>
<tr>
<td>values</td>
<td>Intensive high-cost</td>
</tr>
<tr>
<td>Extensive low-cost</td>
<td>cultivation</td>
</tr>
<tr>
<td>cultivation</td>
<td>Positive wildlife values</td>
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<tr>
<td>Positive wildlife</td>
<td>Negative domestic animal</td>
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<td>values</td>
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<tr>
<td>Negative domestic</td>
<td>Positive domestic animal</td>
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<tr>
<td>animal values</td>
<td>values</td>
</tr>
</tbody>
</table>

Source: Gordon and Bentley, 1990

Agroforestry Systems

Various traditional and modern agroforestry techniques are being used by farmers in different geosystems. The main systems are

- agri-silviculture (Taungya system)
- farm-and-grove system
- tree planting among agricultural crops
- silvipastural combined tree, shrub, and animal production
- home garden systems (agri-silvipasture), and
- alley cropping (wood, green foliage, or green manure for food crops).

Agroforestry: Issues and Opportunities

Around the settlements, a sizeable rural population, particularly the small and marginal farmers and landless labourers, depends on common property resources for its sustenance and other day-to-day social amenities. Those resources generally consist of village or common lands that can be brought under suitable forest species and use to raise seedlings for plantations. Such land should be allocated to the landless population and small or marginal farmers for forestry or agroforestry.

Conservation forestry is emerging as an important sustainable method for balanced production from the natural areas. This takes optimum production of fuelwood and timber from the land and puts in bulk soil humus and fertility.

The cultivation of wastelands, particularly salt-affected soils, requires hardy crop. On the basis of experiment with salt tolerance, the fruit crops have been classified as follows:

1. High tolerance: date palm, ber, tamarind, lasoda.
2. Medium tolerance: anola, phalsa, pomegranate, karonda, fig, ananas, jamun, cherry, spota.
3. Low tolerance: guava, mango, grape, bael.

In wastelands, the plant species grown should have salt tolerance, a deep root system. Some degree of drought tolerance, ameliorative effect on soil properties and relatively fast growth.

Agroforestry may be evolved along with compatible livestock management both of land and water and integrated land and water development planned for various biomass production, regeneration of land resource base, and increase in employment and income. The
development of non-forest areas for their sustainable use would call for regenerating or recreating an integrated, interdependent land management system. This would require people's initiatives and continuous participation of people through non-government organizations and voluntary agencies. More inputs from science and technology will be required in order to derive the maximum benefit.

**Integrated and Sustainable Land and Forest Development Initiatives: Suggested Measures**

i. Development of land information systems and soil mapping on scale of 1:15,000 and 1:50,000.

ii. Preparation of human and livestock carrying capacity based on geoecological principles.

iii. Land capability and irrigability classification.

iv. Prioritization of critical land sensitivity and regions.

v. Understanding land use and forestry response.

vi. Integrated strategy for surface water, ground water, and rainwater through water harvesting pond.

vii. Diversification of agriculture through agroforestry, horticulture, oilseeds (sunflower), sugarcane, fruit, and vegetables around urban areas.

viii. Natural Principles of agriculture through crop combination and integrated fertility management.

ix. Development of four-tier forestry systems i.e. block forest along rivers, strip forest along roads, railway and common property, stray plantation along bunds, wells and farmhouses, agroforestry on croplands.

x. Use of people's indigenous knowledge in management strategy.

**References**


Chaudrun D.P., R.B. Singh, Deb and A.A. Pirazazy 1991, Land use Sustainability and Agricultural Development in the North-West India (1951-88), Report prepared for Ministry of Agriculture, Govt. of India.


