Biodiversity, Gender and Technology in Mountain Agriculture

Glimpses of the Indian Central Himalayas

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Respect for the Natural Diversity of the World in its Plants, Animals, Soils, Waters and Peoples is the only way to Survival

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To see a world in a grain of sand
And a heaven in the wild flower
Hold infinity in the palm of your hand
And eternity in an hour.

– *William Blake*

Responsibility for life at large obliges us to support diversity, for diversity is not only the spice of life, it is also a precondition of vibrant and healthy life; moreover, a precondition of the meaningfulness and richness of our individual lives.

–*Henryk Skolimowski* (1995)

As the fundamental building blocks for development, biological resources provide the basis for local self-sufficiency. At the same time, biological diversity is a global asset, bringing benefits to people in all parts of the world. Efforts to maintain the diversity of biological resources are urgently required at local, national, and international levels.

– *McNeely* et al. (1990)

Nature is a complex mosaic of phenomena. When we observe it, we are unable to 'see' or 'take in', or comprehend it in its totality. We mentally focus on certain aspects, often to the complete neglect of other aspects.

– M.G. *Jackson* (2002)

Seeds and livestock breeds have been exchanged, traded and sometimes stolen during most of the history of agriculture. There was no need to discuss the rights of farmers or pastoralists, as the genes remained accessible to all.

– *Gura, Susanne* (2003)

Biodiversity and Genetic Diversity

Biological diversity, or as it is also called, biodiversity, encompasses all species of plants, animals, and micro organisms and the ecological processes of which they are parts. Or: the variety and variability among living organisms and the ecological complexes in which they occur. Genetic diversity in this context is defined as the sum total of genetic information (contained in the genes) of individuals of plants, animals, and micro-organisms that inhabit the Earth (McNeely *et. al* 1990). Personally we would prefer a definition referring to the variety of interspecies and intra-species life expressions.

Species diversity has been defined as the variety of living organisms on Earth. It is estimated that there must be between 5 and 30 million species although only 1.4 million have actually been described (Wilson 1988). That shows that the current state of knowledge about species and ecosystem is completely inadequate. Biological resources (genes, species, and ecosystems that have actual and potential value to people) form the basis for life on Earth. Species are the building blocks of ecosystems and ecosystems provide the life-support systems for, e.g., humans.

When we look at biological resources from a human perspective, several different values can be described (on a scale from ecocentric to anthropocentric). To our opinion the ethical values (including the symbolic-cultural) should be starting point for an appropriate and sound attitude of humans and their institutions towards nature. These values which can still be distinguished in local situations in rural areas are often neglected and put apart, especially in recent conservation discussions.

However, some efforts have been made to underline these officially. An example of such an effort forms the World Charter for Nature, which was adopted by the General Assembly of the United Nations in 1982, and recognises that human kind is a part of nature, that every form of life is unique and it warrants respect towards nature regardless of its (utilitarian) worth to human beings.

We agree completely with Ehrenfeld (1988) saying:

"It is certain that if we persist on this crusade to determine (economic) value where value ought to be evident, we will be left with nothing but our greed when the dust finally settles…"

Anyhow, certain classifications of values of biological resources have been developed such as (McNeely 1990):

a. Direct Values

(1) Consumptive Use Value (non-market value of firewood, fodder, water, medicine, game, etc)
(2) Productive Use Value (commercial value of timber, fish, crops, etc.)

b. Indirect Values

(1) Non-consumptive Use Value (scientific research, recreation, etc.)
(2) Option Value (value of maintaining options available for the future)
(3) Existence Value (value of ethical feeling of existence of nature, etc.)

In this classification we miss – as a direct of indirect value – the Life Support Value, which corresponds to the maintenance of ecological processes.

The diversity in biological resources – genes, species, and ecosystems – provides the basis with which different human conditions can adapt to changes, and the basis for many different social, and cultural expressions as well. And it is the tropics, which harbour the major proportion of the plants' biological diversity.

Biodiversity and Domesticated Resources

Human society, agriculture, and Earth's abundant plant sources have been co-evolving for more than 10,000 years. Some 10,000 years ago, agriculture began in several different areas in the world.

Several stages can be recognised in the development of seed agriculture (Hawkes 1969):

(a) gathering and colonisation of wild species;
(b) harvesting; and
(c) sowing and planting.

Most domesticated herbaceous plants and their wild relatives are ecologically weeds; this means: plants with ability to colonise open or disturbed habitats with bare soil, and which are unable to withstand a high level of competition from other plants. Domesticated plants are adapted to permanently man-made habitats which have especially been created for them. During domestication, crop plants were brought into contact with many different wild plants, with which they hybridised and exchanged genes. In doing so the (physiological) adaptation of the plants was increased.

Domesticated species are almost always characterised by wild, weed, and cultivated races. The crop-weed complexes may considerably affect the amount of genetic diversity in a crop, depending on the phylogenetic relationships and the extent of gene exchange between the crop and the weed (Ford-Lloyd 1986).

It was Vavilov (1887 – 1943) who was the first to focus attention on the enormous diversity to be found in crop plants and to the fact that it was concentrated in so-called centres of diversity. He recognised eight centres of diversity, that all lie between 200 – 450 latitude N-S of the equator, in mountainous areas. In these he also recognised differences in agricultural methods. One of the centres is the Indian Centre, another Indo-Malayan.

Many of the cultural plants, according to Vavilov (1920), not only originated in the Central Himalayan region, but also formed a "passport" under which a definite type of cropping pattern developed. This was a combination of human efforts and the natural spread of plant species (Pant 2002).

It may be true that the 'Age and Area' hypothesis of Wills (1922) suggests, namely, that the longer an organism has been present in an area, the more diverse it will be. The pattern of biodiversity seen in crop plants results from the interaction of five important factors, namely gene mutation and migration, recombination, selection, and genetic drift.

The value of landraces (folk seeds) or long-established cultivars often remains unappreciated, and so is the role of their cultivators: local people who have done the selection and cultivation often for centuries. The value of local gene pools for the development of regionally/ locally adapted cultivars cannot be underestimated. Crucial is, in this respect, the knowledge of local people on the agro-ecosystem and its components.

This adaptation to a local situation – including stress and disease resistance – is fundamental in securing food supplies. There are many examples, such as: when attempts have been made in West Africa to cultivate pearl millets which were previously bred in India, they suffered so much from mildew disease that they could not compete with the less highly bred traditional varieties of local origin (Ford-Lloyd 1986; Juma 1989).

The genetic base of most forest trees is generally broader than most of our food crops. The scale of forest genetic resources is quite daunting, because of the large number of actual and potential economic important species, and the fact that these species are components of some of the largest and most complex ecosystems known to man.

However, little (or no) information is yet available on intra-specific variation in a large number of tropical trees, which today are receiving increased attention as providers of goods and services for rural communities (Ford-Lloyd 1986).

Wild biological resources still contribute considerably to the production of domesticated resources, namely:

- wild resources are used to improve established domesticates (a contribution valued as billions of dollars per year);
- rangeland and wild forage species contribute to livestock production;
- wild species – especially of plants – serve as sources of new domesticates;
- wild pollinators are essential to many crops, and the wild enemies of pests help control their depredations on crops.

The productive value of wild genetic resources demonstrates that genetic resources are indispensable to agriculture. The wild relatives of domestic plants – most of which come from a country other than where they are utilized – as well as the conservation of a maximum variety of landraces (folk seeds) in their original agro-ecosystems are essential components of ensuring food security at all levels of society for the next century (Hoyt 1988).

In the context of this study, we will specifically focus on the agricultural systems in the Indian Central Himalayas, in which, originally, the forestry, animal husbandry, and crop cultivation sectors are closely connected via biomass flows. Central to our determination of biodiversity will be:

(a) the co-existence of these sectors and their linkages;
(b) the diversity of species within each sector; and
(c) the diversity of varieties of each species.

In other words, not only the components (sectors, species, varieties) as such are of importance, but also their linkages.

However important biodiversity proves to be, uniformity is now replacing diversity. Nowadays, for example, every major crop that is grown commercially has a very narrow genetic base. And it is this as well as the disruption of natural biomass flows and the increase in monoculture cropping patterns which make these systems so ecologically vulnerable.

The Erosion of Biodiversity: A Characteristic of the 20th Century

Today's threats to species and ecosystems are the greatest in the recorded history; virtually all of them are caused by human mismanagement of biological resources, often stimulated by misguided economic policies and faulty institutions that enable the exploiters to avoid paying the full costs to their exploiters (McNeely 1990).

In the evolution, the extinction of species is a natural phenomenon. However, since the entering of humankind in the industrial age and particularly during the past 40-50 years, the extinction and replacement of an exponentially growing number of species is becoming a very serious problem. Today the extinction rate of plant and animal species is probably 40,000 times higher than ever before in the history of the Earth, and practically all ecosystems are threatened by humans. That is not only the case with regard to wild species, but also for the domesticated ones.

There are many different causes of this genetic erosion, but the main background of it has been (and still is) a development process in which material profits and economic growth prevail, and in which nature and natural resources are treated as a free, inexhaustible resource. This development concept (or paradigm) has favoured some people – quantitatively – but has marginalised many others (especially those living in the rural areas of the Third World). These developments and the socio-cultural changes which were promoted by the Western colonisation process and modern imperialism have reinforced population pressures on the natural environment. The use of natural resources for the greed of some has deteriorated the needs of many, Mahatma Gandhi would say.

This development process is fielded by a scientific worldview which originates from the 15th Century (Bacon c.s.) and in which nature is seen as a subject, for the use of men, which has to be tamed by science. The technologies which were the result of scientific developments within this paradigm inherently incorporated this 'scientific' worldview in their characteristics.

Still the Earth looses much of its natural ecosystems through this dominating development concept: deforestation, Over-exploitation of pastures, land, and waters, all result in a decrease of natural habitats of wild species and landraces. Another important feature of this development process is the production of waste and emission of polluting substances in the environment. This poses another important threat to biodiversity. Finally, the direct over-exploitation of many natural resources threatens their mere survival.

In the late 1950s, the research centre near Mexico City, which was later called the CIMMYT (International Maize and Wheat Improvement Centre), was among the first to create high-yielding wheat varieties, which formed the basis of the Green Revolution in India. Private capital and global aid provided inputs for this capital and resource intensive and profit oriented farming system. At the heart of the Green Revolution were so-called 'miracle' seeds: hybrids through which development and production were mainly controlled by the international agricultural research institutes and Multinational Corporations.

The introduction of these seeds meant the destruction of the self-producing character and genetic diversity of seeds. Formerly throughout India – even in years of scarcity – grain for seed was conserved in every household so that the cycle of food production was not interrupted. Now the farmers had to buy new supplies of these every year as these do not reproduce themselves. This resulted in a loss of the peasant's control over seeds and their selection, an increase in their dependence on the private sector and on the cash economy and wage labour. Their traditional control over land and agriculture ended as land which was formerly used for subsistence agriculture (specially the best quality land) was overruled by cash crop production. As the Green Revolution was mainly building on "the best", which meant the richest farmers of the richest regions in India, a concentration on already privileged farmers took place and the poorer peasants, particularly women, were further marginalised.

The Green Revolution has not just displaced seed varieties but entire crops in the Third World, like – in India – *ragi* and *jowar*, *mandua* and *bajra*: often well-adapted indigenous crops of very high nutritive value.

Bathua (*Chenopodium* spp.), a green leafy vegetable with very high nutritive value, which the women collected as a "free" resource, was declared as a weed by agricultural extensionists and killed with herbicides. Pulses such as green and black gram – not only so important as source of protein in India, but also because of their fixation of Nitrogen in the soil – and oilseeds have either disappeared or had to be cultivated exclusively. This has put a new demand on the land. Not only was biodiversity reduced and uniformity increased by the Green Revolution, also has the so-called plant improvement in agriculture been based on the enhancement of the yield of desired products at the expense of unwanted plant parts. The "desired" product is however not the same for agribusiness and the Third World peasant. What is unwanted for agribusiness may be wanted by the poor. In Central Himalayas, for example, at least much of the fodder needs of farm animals are derived from the straw of cereal crops. The shift to dwarf varieties of cereals, which produce far less straw, and the shift to vegetables destroyed not only the supply of food and fodder for the animals, but also increased the pressure for fodder from forests immediately. This contributed to forest degradation soil erosion and water depletion. A decrease in the number of animals also meant a reduction of manure and thereby of soil fertility.

So by squeezing out those "unwanted" aspects of biodiversity the agricultural "development" has fostered ecological destruction and the breaking of natural cycles of the agro-ecosystems.

That monocultures are ecologically unsustainable and invite diseases and pests is experienced already all over the world, e.g., in 1970-71 in the US with the corn blight epidemic which laid waste 15 percent of the nations crop; 80 percent of the hybrid corn in the US in 1970 was planted with corn which contained *T. cytoplasma*, which was vulnerable to corn blight. In South East Asia, the new IRRI rice variety IR-8 was attacked by bacterial blight in 1968 and 1969. In 1970 and 1971, it was destroyed by the hungro virus. And in 1975, pests destroyed half a million acres under the new rice varieties. Rice cultivation in Punjab is vulnerable to 40 insects and 12 diseases, whereas insects and pests were considered insignificant in the State before the Green Revolution (Doyle 1985).

In Pakistan in 1968-69, for example, the yield of Mexican dwarf wheat declined by about 20 percent because of 2/3rd reduction in rainfall, whereas local variety production increased by 22 percent. Prior to 1962, India did not have virus diseases, but they came in the country with the dwarf variety of rice from the IRRI. These so-called high-yielding by themselves, need heavy inputs of irrigation, chemical fertilizers and – as may be clear from the above – pesticides. So they could better be called "high-responsive varieties", because without these inputs the yield would be low. Widespread irrigation causes water logging, a reduction of essential minerals and salinization because of evaporation. More than a third of all land under irrigation is subject to these effects. In some areas, 80 percent of the irrigated land has been destroyed in these ways. Worldwide, salinization alone may require the abandonment of as much land as is now under irrigation (World Resources 1986). The water demand of these high-yielding varieties causes serious (drinking) water problems all over India.

Synthetic petroleum-based fertilizers are the cause of serious soil and water pollution worldwide. Experiments show that this kind of agriculture affects the metabolic balance in plants, leaving them more vulnerable to attacks from pests and diseases. Farmers are then caught in the vicious circle of increasingly intensive (and costly) use of pesticides, which in turn causes greater pest infestation.

There is a growing concern over the developing immunity of many pest species as pesticide use accelerates. The use of pesticides has serious consequences for health. During informal consultations in 1985, the World Health Organisation estimated that one million cases of pesticide poisoning occur annually. Not only human beings, but many other non-target species – and livelihoods based on them – are affected by pesticide poisoning, including livestock, fish, birds, and bees. In many South Asian countries, for example, food from fish in rice fields is destroyed by weedicides.

International research institutes (such as IRRI) and international corporations have extracted biological and gene material from the Third World and have thereby also eroded the decentralised knowledge system of Third World peasants (often women) and Third World research institutes. For example, the work of the Central Rice Research Institute in Cuttack (India) – which was working on rice research based on indigenous knowledge and genetic resources – was made impossible under international pressure, when its Director resisted handling over his collection of rice germplasm to IRRI, as well as asked for restraint on the hurried introduction of the HYV rice varieties from IRRI (Shiva 1990).

All these effects of the Green Revolution lead to the reduction of biodiversity in species and varieties, the breaking of (agro) ecological circles and pollution of the environment, as well as loss of control by the local producers over agricultural production, a decrease in their access to natural resources and greater dependence on external actors and inputs.

That high-technological agriculture not only has many negative effects on both the environment and society, but is also not necessary was shown in September 1989 when the National Academy of Science in the USA released a study in which it was demonstrated that farmers who apply few or no chemicals to crops are usually as productive as those who use pesticides and synthetic fertilizers. Well-managed alternative farms use less synthetic chemical fertilizers, pesticides, and antibiotics without necessarily decreasing, and in some cases even increasing per acre crop yields and the productivity of livestock systems (International Herald Tribune, 9-10 September 1989). Wider adoption of proven alternative systems would result in even greater economic benefits to farmers and environmental gains for the nation.

In India alone a rough investigation showed that in more than 65 places ecological agriculture is successfully being practiced by individual farmers or organisations (Mansata and Menon 1989).

Ecologically, the cow has been central to Indian civilisation. The sanctity of the cow as a source of prosperity in agriculture was linked to the need for conserving its integration with crop production. The cattle provide organic fertilizers for fields: each year they excrete 700 million tonnes of recoverable manure, half of which is used as fertilizer. The other half is used as fuel, of which the thermal energy is equivalent of 27 million tonnes of kerosene or 68 million tonnes of wood. More than 2/3rd of the power requirements of Indian villages are met by some 80 million work animals. To replace animal power, India would have to spend more than 1000 million US Dollars annually on petrol. Milk is just a by-product, though important for the local diets and for the indigenous diary production of products such as ghee, buttermilk, curds, cottage cheese, and *khoya* (casein).

The White Revolution, however, was introduced from the West to replace pure indigenous breeds by homogenised hybrids of the Zebu cow with exotic stains like Jersey, Holstein-Friesian, Red Dane, and Brown Swiss. The only objective was to improve the dairy productivity. The cow was merely seen as a milk machine; all the other functions were neglected. As George (1985) comments: "When the milk produced by Danish and Indian cows is compared, it might be instructive to ask how the work performance of the Danish bull measures up to that of his Indian counterpart."

The crossbreds need intensive inputs of resources: each crossbred cow uses about 2 million calories of food per day, or the annual food supply of two persons. This food consists merely of hybrid crops, high inputs of green fodder and concentrated feeds, which puts much pressure on the land. The indigenous cattle use crop wastes, uncultivated land and other waste, do not compete with man for food and have very efficient food conversion.

Further, the indigenous breeds are very well adapted to the Indian climatic conditions as they have an extra epidermal area and light skin colour for increased heat tolerance, a long tail and long ears to keep insects away and a hump to store muscular fat. The crossbreds, however, are not only maladapted to the climate, but their disease resistance is drastically lower than that of indigenous stock and they brought with them many new ailments, such as viral pneumonia, tuberculosis, and ephemeral fever.

Milk was converted from a free product to meet basic rural needs into a commodity for sale to meet the needs of the urban elite. Moreover, the centuries-old breeding strategies which were evolved and maintained by indigenous experts were overruled by the improved dairying practices of so-called scientists.

So the White Revolution, which was guided by reductionist principles, has not only resulted in the displacement of well-adapted and multifunctional indigenous cattle, and has ecologically caused a breakdown of the integrated nutrient cycle in the agro-ecosystem, it has also marginalised and eroded local knowledge and control over resources and – again – increased dependence on external inputs.

A similar picture becomes evident when we look at so-called "scientific" or social forestry, which developed and was promoted during the last 20 years. Decentred agroforestry, based on multiple species and private and common tree stands, has been India's age-old strategy for maintaining farm productivity (especially in arid/ semi-arid zones). A wide variety of species, such as the honge (*Pongamia globra*), neem (*Azadirachta indica*), tamarind (*Tamarindus indica*), jackfruit (*Atrocarpus heterophyllus*), mango (*Mangifera indica*)*, jola (Acacia fernesiana), gobli* (*Acacia catechu*), *kagli*, and bamboo traditionally provided food, fodder, fertilizer, fibres, fuel, pesticides, and small timber to the local communities. But, throughout the Third World, forestry got dominated by industrial plantations of monoculture non-local species, such as Eucalyptus and Poplar, and reserve management, which made prior commons inaccessible for the local people. The perception of forest ecosystems as having multiple functions for satisfying diverse and vital human needs for air, water, and food, has been replaced by a one-dimensional perspective in which only an increase in timber yields to serve commercial and industrial demands for pulp and timber was calculated. Not only was the biodiversity of the multi species forest replaced by uniformity, also original grazing and agricultural lands for local use were reafforested, which – again – increased the pressure on the land. In India, for example, it was an incentive for farmers to exchange irrigated food-producing land for Eucalyptus plantations, and the schemes were only profitable for large landowners, whereas they deprived local communities from access to fodder and fuel. The biomass flows from the forests to the animals and people, which sustained the ecological cycles in the agro-ecosystem, were broken down.

The imported tree species were not well-adapted to the local situation. Particularly Eucalyptus has had many negative impacts on the water balance and soil productivity, as it guzzles nutrients and water and in situations of low rainfall tespenes the soil, which inhibits the growth of other plants and is toxic to soil organisms.

Although it is pretended that the production of the fast-growing trees is high, this is only a miscalculation: local species like tamarind and jackfruit have very short rotations of one year and the biomass harvested from these is far higher than that of Eucalyptus, as long as fruit production is also taken into account.

With the imported seeds and distributed seedlings, the local knowledge of and involvement in the management of the forest within the agro-ecosystem is vanishing as well.

In conclusion, it is obvious that the scientific-technological developments in agriculture (including animal husbandry and forestry) of the last 40-50 years have:

- replaced diversity of local species and varieties by uniformity;
- introduced species often not well adapted to the ecological situation and increased the vulnerability for pests and diseases and disrupted (agro-) ecological balances and biomass flows;
- increased the pressure on the land;
- commercialised production and made local communities and peasants more dependent on the money economy (wage labour) and external inputs;
- reduced the access of local people to natural resources, not meeting their multiple needs;
- eroded the local knowledge about the agro-ecosystem and its species and thereby also the local cultures.

Biodiversity and Biotechnology

Modern biotechnology is one of the most recent scions to scientific development. Although there are several scientists who assert that modern biotechnology (including tissue culture and genetic engineering) will broaden the spectrum of utilized genetic resources, there are strong arguments to prove the opposite. The characteristics of biotechnological developments intrinsically will increase the erosion of biodiversity.

The governmental policies in India presently very much support the development of an Indian biotechnological capacity in Research and Development (R&D). The biotechnological research is mainly focussed on crop species such as wheat, rice, and the oilseed *Brassica* and to a lesser extent on potatoes. Among the tree species much attention goes to bamboo, Eucalyptus, teak, sandalwood, oil palm, *Leucaena* spp., *Populus, Acacia,* and *Prosopius* spp., and, among the fruit trees, to papaya and bananas. Animal research is primarily aimed at cattle and buffaloes.

This national R&D is focussed on the large-scale production and faster multiplication of these so-called elite plants and weeds. They are high-yielding and/ or fast-growing and do have economic/ commercial value. Also greater stress tolerance and resistance are among the characteristics which get much attention. It has literally been expressed that immuno contraception in animals is being promoted to “breed out low-grade genetic stock of little economic value”, but also in biotechnological R&D in agricultural crops and trees it is a motive.

So biotechnological developments have primarily a profit motive as they are, to an important extent, based on the private sector.

Biotechnology will affect all species and is focussing at large scale applicability; this means the breeding of uniformity (with a so-called superior quality and broad range) in plants (cloning) and animals.

These trends in biotechnology mean that:

a. only certain species will be promoted strongly at the expense of many others: uniformity will increase;
b. as Kloppenburg (1988) has warned: “though the capacity to move genetic material between species is a means for introducing additional variation, it is also a means for engineering genetic uniformity across species”;
c. the wider adaptability of the engineered species makes that they will be applied on a larger scale, which will again decrease biodiversity;
d. much of the research is focussed on the increase of yield or production and not (so much) on the other functions of the crops, trees and animals for the people and for the linkages between the different sectors;
e. no account is being taken at all of the ecological relationships in which each species has its own need and function;

So it can be concluded that these biotechnological developments will:

1. even more breakdown the circles of biomass flows between the different sectors of forests, animals, and crops;
2. will stimulate the decrease of species diversity;
3. and among these the diversity of varieties.

Further on, the national and international policy measures and negotiations with regard to patenting, Plant Breeders' Rights, New Seed Import Policy and New Industrial Policy will open up the country even more for the private sector and transnational corporations, promoting external know-how and seed imports from abroad.

This will result in a concentration of plant and animal breeding activities in the hands of biotechnology firms and will displace traditional seeds and local production and producers. This means a loss of indigenous knowledge and culture. Critical scientists, local industries, and NGOs in India oppose these developments.

The genetically engineered products of corporate biotechnology ventures will not only be genetically uniform and ecologically fragile, they will also pose new ecological threats to the existing life-forms (Doyle 1985). The question is as well how a manipulated (or transgenic) species will behave in the field and in (semi) natural circumstances. Introductions of exotic species in the past have shown disastrous effects in this respect.

The fact that hybrid and genetically engineered seeds do not reproduce themselves but need external inputs, make that the ecological processes of reproduction are shifted to the technologies of production.

Local farmers/ producers will loose more of their access to and control over these production processes and will become more dependent on the purchase of formerly free foods.

The issue of patent protection for modified life forms raises a number of unresolved political questions about ownership and control of genetic resources.

Although John Duesing of Ciba Geigy states that "Patent protection will serve to stimulate the development of competing and diverse genetic solutions with access to these diverse solutions ensured by free market forces and work in biotechnological ecology and seed industries", the diversity in corporate strategies and the diversity of life-forms on the planet are not the same thing (Shiva 1990). Corporate competition can hardly be treated as a substitute for nature's evolution in the creation of biodiversity.

Even the international Atomic Energy Agency concluded that the included germplasm mutations (through radiation) are no alternative to the conservation and screening of natural germplasm sources (Third World Network 1990). The problem is that in manipulating life forms you do not start from nothing, but from other life forms which belong to others – may be through customary law. Secondly, genetic engineering biotechnology does not create new genes; it merely relocates genes already existing in organisms.

In making genes, the object of value through the patent system, a dangerous shift takes place in the approach to genetic resources. Complex organisms which have evolved over millennia in nature, and through the contributions of Third World peasants, tribal, and healers are reduced to their parts, and treated as mere inputs into genetic engineering. Patenting gives their leads to a devaluation of life-forms by reducing them to be repeatedly owned as private property.

Centuries of innovation are totally disvalued to give monopoly rights on life forms to those who manipulate genes with new technologies. Thereby they place their contribution over and above the intellectual contributions of generations of Third World farmers for over ten thousand years in the areas of conservation, breeding, domestication, and development of plant and animal genetic resources.

This reductionism and fragmentation might be convenient for commercial concerns, but it violates the integrity of life, as well as the common property rights of Third World peoples.

Conservation of Biodiversity

Since the end of last century, but with far more emphasis during the last few decades, several strategies have been developed to conserve biological and genetic diversity. Most common strategies are:

a. In-situ Conservation

This involves protection of habitats by the establishment of parks and reserves. This is applied mainly to wild species. It is often felt that species should be preserved within the genetic integrity of their natural environments, as this will also enable a continued natural evolution. Worldwide strategies, such as UNESCO and WB/ IUCN programmes, are aiming at conservation of biodiversity in this way.

b. Ex-situ Conservation

This can include the use of botanical gardens, arboreta, and zoos, but in this context gene banks and in-vitro storage of germplasm get most attention. A way of maintaining plant germplasm is by storing seeds in (a) long-term base collections, or (b) medium-term active collections. Seed is stored in a controlled environment room, where as a medium requirement the temperature can be maintained at -18^{0}C or less.

The gene banks are coordinated by the International Board of Plant Genetic Resources (IBPGR), which was established in 1974 by the Consultative Group on International Agricultural Research (CGIAR). Its primary function lies in the development and administration of the International Plant Genetic Resources Centres and a large number of collecting missions. Its major tasks are the promotion, collection, conservation, and evaluation of plant genetic resources of species of major economic importance and their wild relatives.

In India and many other countries also, a National Bureau for Plant Genetic Resources (NBPGR) is active in exploration and ex-situ conservation of germplasm collections in the National Gene Bank and National Tissue Culture Repository.

Although a number of gene banks have been established in the tropical developing countries in the last 25 years, (still) large collections are held in the developed countries of the temperate region.

Plants which are normally vegetatively propagated and do not produce viable seeds (e.g., banana) or recalcitrant species are in recent years stored via tissue culture or other *in-vitro* techniques. The cultures are sterile and the environment is kept pathogen-free. Tissue cultures can be maintained under normal growth conditions virtually indefinitely.

For the conservation of animal genotypes cryo preservation is being used. This means the freeze preservation of cultured animal cells, spermatozoa and ovarian and embryonic tissues, as well as whole animal embryos. This technique is still under development.

It might be clear – from both described methods (in-situ and ex-situ conservation) – that both have a different focus: in-situ mainly focuses on wild species and ex-situ is mainly aimed at actual or potentially useful crops and animals.

The method of parks and reserves has several disadvantages, such as the fact that local people often loose their access to natural resources to meet their basic needs and that it is often fencing, flower-pot method – not in accordance with recent ecological views, that in open system in which interactions can continue the maintenance of biodiversity is far better guaranteed than in closed situations. This counts even more for agro-ecosystems in which the interactions between the local communities and their environment have been crucial in the management of biomass flows and the creation of biodiversity. Also, external environmental pressures, bad planning and management often put serious pressures on the existing reserves and parks.

Ex-situ preservation has often a utilitarian perspective and takes natural species and genetic material completely out of their natural environment. A forest cannot be replaced by a gene bank. Another problem associated with gene banks and other ex-situ conservation efforts is that local cultivators loose their control over the resources.

Several new efforts are being made to encourage biodiversity conservation. A recent development is to express the value of genetic/ biological resources into monitory terms and to ‘count’ the cost-and-benefits of conservation. However politically applicable this approach seems to be – it is again a danger to valuate nature in economic, utilitarian terms: on the one hand as some values cannot be expressed in money, and on the other hand as profits and manipulation are promoted in this way.

It is obvious that in none of these strategies attention has been paid to the need to integrate biodiversity conservation in overall developments, such as in agricultural, industrial, and physical planning. To be sustainable, however, these developments should be based on the preservation of biodiversity and the integrity of all life forms. This will also result in more awareness of and appreciation for the role and knowledge of the local producers.

Only if ecological considerations are integrated thoroughly in overall development strategies in this way that both species, their varieties, and their linkages are maintained within a healthy natural or man-made environment, the main threats to biodiversity erosion and other forms of environmental degradation, as well as erosion of local knowledge systems will be prevented.

2

Gender and Biodiversity in India

> An enormous number of names were applied by native agriculturists to soils. Each district rejoices in at least a dozen purely local names. Native cultivators keenly appreciate the smallest differences in the relative qualities of different soils. Names have references to external condition, frequency or decency of cultivation, its situation as regards inhabited sites, etc., its position as upland or recently formed alluvium, its occupation for pastures, fields or gardens, its external features, etc.
>
> – *A.O. Hume (1878)*

> If there must be a war, let the weapons be your healing hands, the hands of the world's women in defence of the environment. Let your call to battle be a song for the earth.
>
> – *Mostafa Tolba*

> These oak trees
> save and worship them,
> because
> their roots store water,
> their leaves have milk and fodder,
> the breeze blows cool
> over the beautiful rhododendron flower.
>
> – *Garhwali Women's song*

> They (women) have a profound knowledge of the plants, animals and ecological processes around them.
>
> – *Irene Dankelman and Joan Davidson (1988)*

> To say that women and nature are intimately associated is not to say anything revolutionary. After, all it was precisely just such an assumption that allowed the domination of both women and nature. The new insight provided by rural women in the Third World is that women and nature are associated not in passivity but in creativity and in the maintenance of life.
>
> – *Vandana Shiva (1989)*

> All collective efforts have emerged from and as a result of the organisation of women for collective action, which is required to confront powerlessness. This is a prerequisite for effective sustainable development.
>
> – *Wignaraja (1990)*

Although biodiversity is our starting point, the social and more particularly the gender dimensions are essential as well. In this Chapter, we try to outline the relationships between gender and biodiversity, with specific reference to the situation in India. This part is based on own observations and studies, but also on publications of others.

It is not right to speak about women as if they are one similar group. There are many differences between women of different races, classes, and ages. However, talking about poor women in rural areas in developing countries there are several similarities.

Some past studies have shown that women, especially those living in these areas, play an essential role in the use and management of natural resources (Dankelman and Davidson 1988; Shiva 1988). Generation after generation local knowledge about the natural processes and resources has been transmitted. Women's role in land use has been essential in this context. This not only concerns food production, but also water and fuel supply and the provision of fodder, fibres, fruits, and other natural products. The land use methods which have been developed by these women – such as the use of natural fertilizers, seed selection, soil conservation, crop rotation, mulching, and terracing – are well-adapted towards natural circumstances. Sir Howard, the 'father' of modern sustainable agriculture, already mentioned these gender specific roles in his *Agricultural Testament* of 1940.

It is also obvious that especially where modern technology has been introduced, the perceptions of local women of the natural environment are often more multi dimensional as compared to those of men (Hoskins 1979). Based on existing power structures and the differences in gender roles and tasks, men often prefer commercial returns instead of welfare returns for the family. Whereas a forest acts in the eyes of a woman as a multifunctional system, men tend to focus on one or only a few outputs. Western science and technology are based on a similar reductionistic view and approach. In agriculture and forestry this has resulted in a promotion of monocultures and a loss of crop diversity. The differences in interests between men and women could also lead to a distinction in the perception of the environment by men and women. However, there might also be a great difference in the environmental perception depending on class, age, and environmental situation. The more holistic perception, which sees different matters in a mutual relationship, has been called a feminine perception and a vision which is reductionistic, a masculine perception. The present power structures, which are dominated by (Western) men, make that a masculine perception is often related to men and a feminine vision is often coupled to women, but that is not a precondition.

An important indicator to describe the position of women and gender aspects is a level of women's autonomy. Schrijvers (1986) defines "autonomy" in this context as: "the scope that women have under varying circumstances in which to live their own lives". The introduction of technologies or other interventions could have a positive or a negative impact on the autonomy and position of women.

Important criteria for the autonomy of women are:

a. her access to and control over means of production, such as land and land use, crops and animals, natural resources and ecosystems, education and training, and labour and income;
b. forms of cooperation and organisation of women which will enable and help them to control their own affairs;
c. their control over their own sexuality and fertility;
d. gender conceptions which legitimate women's sense of dignity and self-respect and their right to self-determination (Schrijvers 1986), including woman's perception of her own situation and environment.

Although in this study much attention will be paid to gender differentiation with regard to women's access to and control over means of production, the other criteria are also essential to determine the effects of technological introductions.

Women and Biodiversity

Several studies have already shown that women in Africa, Asia and – to a somewhat lesser extent – in Latin America, play a predominant role in the use and management of natural resources; it is in agriculture, use and management of forest products (like fodder and fuel) and the supply of water. Apart from agricultural and allied field activities, she performs all other household chores. Children, especially girls, assist her.

In several areas in India the key role and position of women in managing the natural cycles in the agro-ecosystem is still evident; for example, in the hill and mountain areas of North India. We will describe the situation there briefly.

In the hill and mountain economy, which is characterised by an integration of forest management, animal husbandry, and cropping, women play a dominant role, as has been shown in several studies. In a study by Usha (1984) on the day-to-day activities of hill women, it was shown that they work more than 16 hours per day and do not take any time to rest. Often only the agricultural work which is done by the help of bullocks is done by males. Further on, in an undisturbed system, men do assist the women, but the rest of the activities are primarily handled by women. They are the actual subsistence farmers in the hills.

Another study by Singh (1987) showed that a pair of bullocks works for 1064 hours, a man for 1212 hours and a woman for 3485 hours in a year on one hectare farm in the Indian Central Himalayas. Bhata and Singh (1987) showed that women in the hill agriculture in Himachal Pradesh did 37 percent of work in sowing, 59 percent in interculture, 66 percent in harvesting, 59 percent in trenching, and 69 percent in tending the animals. And all this is apart from all the household chores, which include the collection of fuel and water.

Further on, in a study in Nepal by Baer (1988), it was estimated that 93 percent of Nepalese women are active self-employed agricultural workers, producing foodstuffs and items that are primarily consumed in the home-based or small scale manufacturing of agro-forestry products, livestock, and mineral-based or textile products for sale in markets.

Her contributions in the animal husbandry are as follows: she harvests the crops and stacks the hay for domestic animals, she transports the leaf fodder and bedding material over long distances on difficult terrain, she grazes the cattle on distant grazing lands, carries animals to water sources for water, takes care of young calves, milks the animals, cleans the animal shed and executes all other activities related to animal husbandry, except the ploughing, castration, purchase, and sale of animals (Singh 1987).

Contribution of a mountain woman in dairy production system, like in all other land-related activities, is enormous. Quantitative information provided by Singh and Tulachan (2001) reveals that a woman, on an average, devotes as many as 1779 hours to different dairy operations annually. A man, on the contrary, devotes only 315 hours. Woman's contribution to dairy farming in the mountains of the Indian Central Himalayas (Uttaranchal), in terms of the total time devoted to different operations, is as high as 85 percent. Collection of bedding material, fodder, and feeding/ grazing of animals consumes the maximum hours of woman's work.

But also in other agricultural activities her role is evident. Women know everything about the cultivation practices of indigenous varieties of food crops. For example, in Henwal Valley of Garhwal Himalayas, where they do almost all the farm work themselves in local paddy fields, including the seed selection of indigenous rice varieties.

Gay, in a study of 1983, recorded that women rice growers in central Libena used and recognised well over hundred varieties of rice. During an experiment, the women identified 25 rice stalks with at most two or three errors, whereas the men could hardly get two or more correct answers. These women not only described the rice, but also mentioned several other features, such as the ease with which husk can be removed, the length of time required to cook and suitability to different ecological conditions (Shiva *et al.* 1990).

Since – as will be described in the next Chapter – hills/ mountains are the rich repositories of biodiversity, women's role in seed selection and vegetative propagation is essential both for agricultural practices as well as for biodiversity conservation.

In a small sample participatory study with women hill farmers in Dehradun, we were provided with not less than 145 species of forest plants that women have knowledge of and which they utilise. Hill and mountain economy is one in which forests, food crops, and livestock management are closely linked through biomass flows. Women's role in keeping these linkages and biomass or resource flows going is essential. It is through these linkages that ecological stability and sustainability is maintained.

The labour inputs, largely of women, make the resource flows possible, as she carries the fodder, fuel, and other minor forest products from the forest to the animals and the households; she brings the animals and the dung to the fields and feeds the animals with crop residues and the family with the field crops.

So the most critical input in the system, which provides the woman and her family with all the essentials (food, fodder, fuel, medicines, etc.) to fulfil their basic needs, is woman's work and knowledge. In fact, women in these hills are the wheels of the vehicle of economy, as Sajwan (1986) concludes.

When we try to analyse this situation according to the concept of autonomy, the following picture becomes clear.

- in the traditional agro-ecosystem of the hill regions women's access to and control over means of production, such as forests, land and land use, crops, animals, other natural resources, and ecosystems is considerable;
- her access to and control over the form of training and education needed in that particular environment is also present, as the knowledge system on the environment are transferred from mother to daughter, generation after generation;
- with regard to women's access to and control over her own labour, it is clear that she has control over her own labour (although it is merely a necessity to put in her time in the various activities) and that of her children; not over that of her husband; to what extent patriarchal control over women's time plays a role here is not yet clear;
- and with regard to access to and control over income, it is obvious that in an intact hill agro-ecosystem monitory income is not a condition for survival at all; it is the productivity of the environment which supplies the women and their families with a form of natural income;
- about the forms of cooperation and organisation of the women which will enable and help them, to control their own affairs, it is well-known that women (and girls) often do much of their collection and agricultural work together; it is usually a small group of women or girls which

goes out to the forests or the springs; a fact is that the women in the Himalayas, especially in the Garhwal region, have shown a very eminent picture of cooperation and organisation in their collective effort to prevent the felling of the forest: the Chipko Movement;

- about the (traditional) control by the women over her own sexuality and fertility in the hill regions, we do not have much information; but what is obvious is that the population in these areas was stable for a long time (which might indicate traditional birth control measures, e.g., through herbs); on the other hand pregnancy and birth are a part of daily life here, not extraordinary states, that will interfere with the daily activities; women in their third trimester of pregnancy will be found still working in the field; the general practice in the Tehri district in Garhwal is to provide a mother and child with a straw-bed in the cattle shed for as long as twenty-one days as the mother is considered 'achhut' (unclean); girls are married off at an age of 14 to 17 years; and
- finally with regard to women's sense of dignity and self-respect and their right to self-determination – as related to gender conceptions – there might be an indication in their cultural expressions in their songs and dances and resistance to modernisation and commercialisation processes; they not only will then loose their control over resources, but also their sense of dignity (their knowledge becomes worthless) and self-respect. What is also striking is the fact that women are usually very much aware of the conflict in their interests and the interests of their husbands (e.g., resistance against fruit trees as compared to fuel-fodder trees). The heritage system in the Garhwal region is patrilinear.

Our conclusion is that in the traditional hill agro-ecosystem of the Garhwal Himalayas, the autonomy of the women is/ was quite obvious.

The Impact of External Influences

However, recent developments, mainly during the last five decades – but already starting with Western colonisation – have deteriorated the local systems and therewith the autonomy and position of women.

Already in several studies, such as in *Staying Alive* of Shiva (1988) and *Women and Environment in the Third World* of Dankelman and Davidson (1988), it has been indicated how modernisation processes in cropping, forestry, animal husbandry, and water management have had a destructive effect on both women and their environment. In the context of this study, we will restrict ourselves to the situation in the above mentioned area, the mountain community in Central Himalayas, Particularly in Garhwal.

As will be pointed out in the next Chapter, recent developments have had serious effects on the sustainability of the agro-ecosystems in the mountain areas. In fact, when the system gets disturbed, this also has consequences on local women. Also here, with the disappearance of the forests, women have to walk longer distances on rugged terrain. A case study from the Chamba Block Tehri district in Garhwal Himalayas shows that a woman, on an average, has to walk 5460 km per year now to gather firewood. The degradation of the natural vegetation has put a lot of drudgery on them (Singh 1988).

Whereas, as has been mentioned before, local women in the Garhwal region could list 145 species of trees and their uses, the "new" forestry experts, in contrast, were able to name only 20 species of pine and five species of *sesham* (ICIMOD 1989). This indicates the differences in knowledge on local genetic resources of local inhabitants and so-called (external) experts. Another impact of resource scarcity is that women are spending increasing amounts of time in the collection of fodder. Often eight hours daily are spent in this task. Groups of women are forced to go on overnight treks to fetch fodder from forest areas outside of their communities. This also leads to new insecurities, such as the fear for sexual threats (ICIMOD 1989).

Women's crucial role in agriculture is gradually diminished by the introduction of new agro-technology and crop varieties, which are aimed at the males. Women's role becomes more and more that of a labourer, losing her control over production and access to resources. In the Henwal Valley of Garhwal, for example, where the women used to grow indigenous varieties of rice, the new high-yielding varieties are completely directed at males and commercial interests. Dwarf varieties, for example, which are promoted in the Green Revolution, reduce the straw biomass for fodder and fertilizer and hence reduce biomass flows that ensure the sustainability of women's livelihoods in agriculture. In the rain-fed agriculture animal waste and crop residues are essential for the sustainability of the soils. A reduction of straw biomass leads to a reduction of organic manure, thus contributing to declining soil fertility and reduced food production.

A greater incidence of women's suicides corresponds with those areas where the hardship level has reached critical limits, especially there where new crops have replaced local varieties and women's access to resources has diminished (ICIMOD 1989). The replacement of local varieties with so-called new varieties creates resource scarcity in the farming system. The shift, for example, from local pulses to introduced soybean implies a shift from domestic to industrial food processing, displacing women from their resources (Singh 1998a). Much of the present agricultural research is concentrated on increasing the yield of only certain parts of a crop (Jiggins 1984). The potato and mustard crops provide fresh leaf vegetables in the mountain diets. The HYVs of these crops do not.

Weeding is predominantly women's work. The fertilizer use, needed for the HYVs, has stimulated weed growth dramatically, increasing women's work burden again. The off-season vegetable farming for export, presently one of the most popular development strategies for hill agriculture, has had similar effects of reducing biomass inputs for sustainable management and increasing women's work. For example, the replacement of coarse grains, such as millet, by vegetables for export reduces not just the local food availability, but also seriously impairs the availability of fodder. A rough estimate shows that the cultivation of such crops on one hectare of land adds three hours to the daily work burden of women (ICIMOD 1989).

With the introduction of the Chamba-Mussoorie fruit belt, the women lament that all these new farm seeds and inputs make them destitute of all their knowledge about the farming. And the changing cropping patterns and uniformation even adversely affect the cultural expressions in the Garhwal region, which were rooted in the traditional crops and cropping systems.

The dairy development programmes which were aimed at the marketing of milk, led to a monopolisation of fodder resources of the village commons by rich landlords and denial of free access of fodder to the poorer women. As a Haryana woman puts it: "Now I have to steal the grass for my buffalo and when the landlord catches me he beats me" (Shiva 1988). Further on, more and more evidence shows that the women are unable to manage the crossbred animals, as their feed and other requirements are quite different from that of their indigenous cattle (Singh 1988, 2000). Concentrate feed changes the texture and composition of cow dung, making it unsuitable for women's use in managing soil structure.

A study in Garhwal by Manju Mehta reveals that the shift from subsistence to commercial agriculture, through the introduction of cash crops and the market economy, has led to a reduction in women's sphere of influence and an increasing dependence on men for extension services, purchase of seeds, and handling of tools and money, indebtedness is increasing (ICIMOD 1989). It is, for example, a serious trend that instead of bride prizes now dowries are being paid in the hill region. These developments threaten the position of women in particular. Further, their collective action to cope with resource shortages has been gradually eroded away.

Indicative for the present situation is further the fact that as their work burden has increased, in certain areas in Garhwal women are already brought out of the cattle shed just eleven days after delivery, so that they can continue their work.

Conclusions

The above cases have shown that the introduction of new agro-technologies within the context of industrial-commercial market systems, are based on a sectoral, fragmented, and reductionist approach. The market-integration has resulted in resource fragmentation. The traditional biomass flows, maintained by women, get disturbed and linkages between the different sectors of the system – food crops, forests, and livestock and their linkages – break down. Inputs and outputs become completely dependent on external markets and flows, whereby the inputs are not rightly adapted to the agro-ecosystem.

This process means that:

- women's control over the natural resources (including land, water, and species) and the flows in the agro-ecosystem (nutrients, etc.) gets lost;
- the replacement of local varieties/ landraces and biodiversity through a one-dimensional commercial option in agricultural sciences and policies causes loss of essential sources and elements to meet women's (and their families')

needs (e.g., for fuel, fodder, and minor forest products);

- food availability gets reduced, that hits women first;
- the vulnerability of the system increases and the ecological deterioration it causes makes women's position very uncertain;
- they loose their control over labour as a result of changing labour structures and the increases in their work burdens;
- not only the replacement of diversity by uniformity, but also actual loss of (control over and access to) land and forests (including grazing lands) – through commercialisation and felling, or introduction of cash crops (HYVs) – makes women's work more difficult and increases her work burden;
- the de-skilling and de-intellectualising of women, through ignoring their contributions in management, knowledge, and experience in the system, results in a loss of women's knowledge with regard to forestry, cropping, plant genetic resources, and animal husbandry; it also deteriorates her cultural expressions; and
- women loose their status and decision-making power in the social system; the technology is based on gender conceptions which break down women's sense of dignity and self-respect and her right of self-destination (e.g., by an increase of her dependence on external actors and inputs).

Concluding, one could say that the introduction of new agro-technologies not only has resulted in class differentiation, but also in environmental degradation and gender differentiation. The introduction of the new technologies has led to a reduction of women's autonomy.

"The greatest biological revolution of all times (biotechnology) might well turn out to be the most effective triage against the biology of nature and women, in its response to the profit motive through breeding 'super' plants, 'super' trees, and 'super' seeds. The superiority, of course, will be determined by the reductionist mind, and 'superiority' and 'inferiority' will be new dualism – cultural creations of biotechnology based on criteria of profitability alone. The ultimate ecological and cultural impact of this new reductionism will be the annihilation of diversity and sustainability in nature and of basic human needs and rights as a direct consequence" (Shiva 1988).

3

The Farming Systems in the Central Himalayas

The traditional practices of agro-ecosystem management that have evolved over 5,000 years of trial and error are a set of practices and traditions that should be analysed and understood rather than condemned as an unwelcome remnant of the past. Such understanding is an essential part of appreciating our human heritage. Traditional practices may provide the best base on which to develop effective production systems with no or minimum fuel subsidies, and survival of human population depends on the evolution of solar-powered agro-ecosystems that are stable and more productive.

– Mitchell (1979)

Several entities acquire marginal status when they are linked to dominant entities on unequal terms. In several cases mountain areas too pass through this process.

– N.S. Jodha (1990)

A tree is wisdom
They stand for centuries.
They know everything.
They quietly watch
And learn and learn
They will never tell what they know;
Which is a lot.

– McCord (1990)

Seeing agriculture from the eyes of the peasant has the virtue of getting us closure to truth.

– Valliantos (1994)

The diversity of the world is a fact.
But also its unity.
He who does not see the unity
Lives amidst isolated facts.
Who has grasped the unity
Lives the fullness of life.
The wisdom of life means
Comprehending the unity of the Cosmos.

– Skolimowsky (2000)

The rice terraces in the mountains have been referred to as one of the wonders of the world.

– H. Otley Beyer

The Indian Central Himalayas

The word Uttarakhand was earlier used to denote the hill districts of the Uttar Pradesh State of India. In November 2000, this region was created as a separate State of Uttaranchal. Uttaranchal is geologically defined as the Central Himalayas of India that lies between 29^0 to $31^0$30' N latitude and $77^0$40' to $83^0$40'. Uttaranchal is one of the smaller States of India – 16^{th} in size in descending order – with geographical area of 55845 km^2. The State, from administrative point of view, is divided into two Divisions, Kumaon and Garhwal. The State has 13 districts, namely Pithoragarh, Champawat, Bageshwar, Almora, Nainital, and Udham Singh Nagar in the Kumaon Division and Chamoli, Uttarkashi, Rudraprayag, Pauri, Tehri, Dehradun, and Hardwar in Garhwal Division. Hardwar district originally was not the part of Uttarakhand. It was merged later in the new State of Uttaranchal. The districts are further divided into 49 Tehsils, 95 Development Blocks, 673 Nyay Panchayats, 6561 Gramsabhas, 16583 Revenue villages, out of which 15669 are inhabited. The State has some 77 cities and towns and other urban agglomerations.

According to the Census 2001, the State had a total population of some 8.47 million, with a male-female ratio of 1000:964. The State has very high level of literacy: 72.28 percent overall, 80 percent among male and 60 percent among female.

The Indian Central Himalayan region consists of lofty mountains and high hills ranging in altitude from 250 m to over 3500 m above the mean sea level. On the basis of altitudinal variation, the Central Himalayas can be categorised as sub-tropical (250-

1200 m), sub temperate (1200-1700 m), temperate (1700-3500 m) and alpine zone (3500 m and above).

The mainstay of the population is agriculture characterised by the abundance of marginal, small, and uneconomic holdings. Nearly 65 percent of the total workers are engaged in agriculture. The region is predominantly rural with nearly 78 percent of the population living in the villages.

The Middle or Lesser Himalayan Mountains occupy largest land area within the Central Himalayas. Inhabited by majority of the mountain population, it is the ecosystem that forms the mainstream of the Himalayan Mountains. Nearly 60 percent of the total cultivated land lies in this zone of the Himalayas. Out of this, nearly 30 percent of the agricultural land is in the valley areas, 60 percent on the mid-altitudes and 10 percent on high altitudes.

Terraces on mid-altitudes appear on gentle slopes and form a highly sophisticated part of the farming system representing farmers' traditional art and ethno-engineering.

Some selected pockets in this region, particularly those equipped with irrigation and marketing facilities and where public system has taken special interest, have been transformed significantly. This transformation in some areas in the upper reaches of the Middle Mountains has come up with striking negative changes in the farming system.

On high altitudes in the Middle Mountains, particularly in the pockets where extensive transformation in terms of horticultural crop introduction has taken place, farming operations in many cases are carried out on steep slopes considered to be unfit for cultivation.

The forests in the Middle Himalayas are the most critical and the most important part of the farming system and meet most of the villagers' household needs, such as minor timber for house construction and for agricultural tools and implements, fodder and bedding material for livestock, fibre, wild foods, herbal medicines, etc. But biotic pressure on these forests is excessive and apparently beyond their regenerative capacity.

A macro picture of the Middle Himalayas represents a gloomy ecological situation worrying the local inhabitants as well as the policy makers and development agencies. This zone of the Himalayas has been a hot spot for local socio-ecological movements and external development intervention (Singh 1998a).

The Mountain Farming Systems

The farming system in the Central Himalayas is an overwhelming representation of what is called the solar-powered agro-ecosystem. It consists of four major components inseparably integrated with each other, namely:

(1) forests,
(2) cropland,
(3) livestock, and
(4) households

The mountain agriculture, often left on the periphery of mainstream agriculture, is altogether distinguishable from the agriculture of the plains in the sense that only a few, and sometimes none, of the characteristics of the former are shared by the latter. From whichever development angle one looks at mountain agriculture, it undoubtedly appears to deserve more research attention and careful development intervention than it has actually received. The negative characteristic of the marginality associated with the mountain agriculture gives the impression that its contribution to the overall economy would be non-significant. But, in fact, seeing the positive attributes of diversity or heterogeneity, 'niche' or comparative advantages and human adaptation mechanisms (Jodha 1990 and Jodha *et al.* 1992) inextricably linked with mountain agriculture, it could well be assumed that this has great potential for contribution to the national and international economies. The mountain agriculture could provide the products and ecological services that the mainstream agriculture cannot. A great genetic variability among plants and domestic animals and the whole spectrum of bio-diversity ranging from alpine pastures to sub-tropical forests to marginal foodgrain crops to domestic animals is of great potential value for the worldwide farming in future. In fact, as Partap (1996) rightly says, the marginal lands would be the focus of the new millennium agriculture.

Whereas the mainstream agriculture largely revolves round the cultivated land, the mountain agriculture embraces the most important feature of being holistic and involves all the land-related activities including cropping, animal husbandry, forestry and their inter-linkages (Partap, 1995). The mainstream agriculture is dependent on the external inputs, especially the chemical fertilizers and synthetic pesticides, but the mountain agriculture is self-dependent, being nourished by the inputs grown and prepared within the system. Such a farming system is self-contained and self-reliant. The multi-component farming system having forests, cropland, livestock and human beings as the integral parts of it, represents an overwhelming feature of the solar-powered agriculture. The system also uses natural subsidy in the form of forest biomass and recycled nutrients. The mountain agriculture may thus be referred to as nature subsidised solar-powered agriculture (Singh 1998b).

Mountain agriculture being in transition phase currently witnesses some transformation in some selected pockets. However, by and large, the agriculture is traditional and this is the form of agriculture on which majority of the mountain dwellers is dependent. Whether traditional or transformed, the predominant feature of the mountain agriculture is that the cropped area uses the draught animal power and human muscle power (i.e. the animate energy) virtually for all the agricultural operations. This renewable energy is, as it should be, the part of strategy for sustainable agriculture. The fossil energy is a finite resource and has considerable negative impact on the environment and majority of the farmers in the mountains cannot afford fossil energy-based technology (Singh 1998a).

Forests

Forest is the most important component of the mountain farming systems. In the fragile mountains, ecological stability of the system should be the foremost criterion for agricultural sustainability (Singh 1995). The natural forests harbouring the great measure of biodiversity provide stability and serve as the most important base and input for sustainability to the whole farming system.

Forest ecosystem's contribution may be both direct and indirect, in terms of products and component of an ecosystem. In the form of directly extractable products, a forest provides fuel wood, timber, fodder, fruits, food, etc. and in terms of services to the ecosystem, the system's contributions will be in terms of biodiversity, moisture circulation, nutrient cycling, and the make-up and stability of environmental and physical resource variables (Jodha 1990). These services of agroforestry are system's inputs and contributions to sustainability of an agroecosystem.

Mountain farmers, in order to reduce risks, tend to grow more plants per unit area using a variety of species, multistory structures and temporal arrangement to facilitate relay fashion of crop harvesting. Trees and shrubs in a forest ecosystem also enhance food and nutrition security. There is a large number of species of trees and other woody perennials grown in the forest/ agroforestry systems that provide edible fruits, nuts, buds, flowers, seeds, leaves, oils, honey, medicines, etc. According to a study (Singh 1995), there are as many as 24 trees and other woody perennials in Garhwal Himalayas that provide these food items to the local populace. In addition, there are 52 species providing foliage fodder to livestock (Singh *et al.* 1995), thus contributing indirectly to food production through animal products. This food production through woody perennials, coupled with that from the annual food grain crops in the agroforestry system, might be a key source to enhance food and nutrition security amongst the mountain farmers.

Fuel wood is the most important source of energy in rural mountain areas throughout the length and width of the Himalayas. Majority of the families depends on fuel wood for cooking food. Alternative energy sources are not easily accessible, or are too expensive. Every woody perennial raised in an agroforestry system is systematically used to extract fuel wood. The use of wood as a source of cooking energy also contributes to manage soil fertility indirectly, for in the absence or paucity of it the animal dung, instead of being used as manure, would be dried to be used as cooking food at the expense of health of the soil.

Conventional agriculture, dominating the plains, demands constant supplies of energy, e.g., fossil fuel for operating machines and transportation of the produce. In the agroforestry systems in the mountains, nevertheless – owing to almost no mechanization – the petroleum fuel is hardly in demand. The need for soil nutrients is met instead by farmyard manure and through nutrient recycling management mediated by livestock in the mountain farming system.

A forest ecosystem supplies many other raw materials of vital use in daily life of mountain people. Wood extractable from the trees and other woody perennials is used for manufacturing agricultural tools and implements, for building and supporting of houses, and for furniture, etc. Poles, small logs, branch-wood for roofing or thorny bush wood for fencing is also obtained from the agroforestry system. *Grewia optiva*, a dominant tree species in the agroforestry systems at lower and mid-altitudes in the

Himalayan mountains, is extensively used for extracting fibre, making a large number of families self-sufficient in terms of their fibre requirements for ropes, carpets, etc. Dyes, indigo, gums, medicines, beverages, etc. are the other materials obtainable from forests depending on the specificity of the site. Leaves of some of the trees, e.g., *Melia azederach*, *Juglans regia*, etc. have insecticidal properties and are used by the local farmers in preserving food grains in their stores.

Mountains, often left on the periphery of the mainstream plains, are altogether distinguishable from the latter in the sense that only a few, and sometime none, of the characteristics of the former are shared by the latter. From whichever development angle one looks at mountain agriculture, it undoubtedly appears to deserve more research attention and conscious and careful development intervention than it has actually received. The characteristics of marginality, fragility and inaccessibility associated with the mountains impart some degree of restriction on the intensification-focused approach to sustainability. Diversity or niche, the other two highly positive characteristics of the mountains, however, offer considerable scope for resource-use intensification with conservation and, hence, are helpful in consolidating the process of sustainability.

In the fragile mountains, ecological stability of the farming system should be the foremost criterion for sustainability. Forest – or tree-rich farming system – to supply massive amount of nutrients to livestock and cropland and to contribute to hydrological cycle, owing to its contribution to the processes and functions leading to the ecological stability of the mountain farming system, continues to be an essential feature of the mountain agriculture, though much degradation of forests has already occurred in many areas, and such areas are facing grim consequences (Singh 1998b).

In farming systems, deep-rooted woody perennials contribute to soil organic matter through shedding of their leaves and roots. This organic matter improves soil structure, fertility and water holding capacity. Deep-rooted trees absorb nutrients from greater depths and deposit them on the surface in organic matter so that they are more available to shallow-rooted crops.

Contributing as windbreakers, trees also increase moisture availability by reducing wind and, thereby, lowering evapotranspiration rate. Tree canopies can lower the impact of heavy rainfall, reducing runoff and increasing water filtration into the soil. Moreover, the shade provided by trees lowers soil temperatures reducing evaporation and slowing the decomposition of organic matter. Leguminous perennials may provide still further advantages by adding nitrogen to soil.

Trees, as contributors to biodiversity and natural flows, facilitators of regenerative processes, and producers of diverse biomass, can play multiple roles in resource intensification-centred approaches to sustainable land use (Jodha 1992). Diverse and complex forest ecosystem, apart from enhancing the productivity level, imparts a great degree of resilience to the food production system and ensures farmers' security (Solanki *et al.* 1999).

In addition to maintaining the quality of resource base, the trees contribute to the vitality of the entire agro-ecosystem, which is best ensured when the soil is well-managed. The health of the plants, animals and people is maintained through biological processes (Reijntjes *et al.*1992). Since renewable plant diversity and recycled nutrients in the self-contained mountain farming systems are the basis of soil fertility management, and of natural biological protection of plants, no pollution in the system is caused in that the use of eco-malignant pesticides is avoided. Thus, a forest, or assemblage of trees, provides a base for ecologically sound and environmentally safe agriculture. Farmers' traditional agricultural technologies guarantee a healthy human life. Agroforestry management practices involve the use of an ecosystem's produce as a subsidy for the other component (e.g., forest biomass is used as livestock feed and manure for cropland). Forest/ trees thus help strengthen linkages amongst various components of farming system. This contribution is vital for maintaining ecological integrity of the whole system (Singh 1995, 1998b). Forest's role in biodiversity, natural regeneration, nutrient circulation and recycling, moisture circulation, building and binding of soils, etc. is also vital for infusing sustainability in the whole system.

Livestock

Cattle husbandry in the Central Himalayas revolves round the requirement of agricultural draft and dung for manure and the small yet sturdy and sure-footed local animal breeds serve the purpose (Watson 1928). The agro-pastoral society developed a lasting farming system with high degree of husbandry in animal breeding, crop production, and land management (Pant 2002).

Livestock acquire special importance in mountain farming systems both on ecological and socio-economical grounds. They are an integral part of farming system and a lively 'bridge' connecting two types of land, viz., the uncultivated forest land and the cultivated land. This linkage is crucial for the ecological and economical sustainability of the system. Forests, especially the natural ones, are the rich repository of nutrients, which become a subsidy for cultivated land. These nutrients are transferred to the cultivated land via the agency of livestock. The nutrient transfer takes place in two ways. Forest biomass – tree leaves and ground flora – are fed to the livestock. The biomass is also used as bedding materials in the livestock shed. Both, dung and bedding material are converted into manure which is transferred to the cultivated land. Livestock also recycle the nutrients in the cultivated land. Crop residues are fed to the animals and thus the nutrients in them are recycled into the cropland.

The biomass transfer and cyclic flow pattern of nutrients mediated by livestock infuses vitality in the production system and livestock themselves fulfil their requirements for maintenance and production (milk, draught power etc.). This dynamic relationship among forest ecosystems / CPRs, livestock and agro-ecosystems is vital for sustainability of mountain agriculture.

As indicated above, livestock are interposed in this flow-pattern to capture some of energy and transform it into work and milk. Animals are not essential to the system, for vegetation from CPRs and crop residues can be composted directly, as they are to an extent in Chinese agriculture. Composting, however, is wasteful of energy. Livestock recover some of the energy otherwise entirely lost in the composting process (Jackson 1985).

Two common livestock raising systems are: sedentary and transhumance system. Animals kept under sedentary system are kept in and around the village throughout the year. All animals, except buffaloes, are kept on day-time grazing. At night crop residues and tree-leaves are provided to the animals. Buffaloes and crossbred cows are mostly stall-fed. Buffaloes and cattle are the preferred species. Some families keep few to large number of goats.

Under the transhumance system, animals move to different locations which mainly depend on crop seasons. Sheep and goats are the most preferred species managed under this system. All animals during summer when they are herded on high altitudes, mainly in alpine meadows, virtually stay on grazing. During winter months animals move to the lower altitudes. The nomadic herders generally do not have permanent houses or cultivate crops, while some tribes practicing transhumance, have their own cultivated land and also practice cropping under the traditional livestock- based farming system.

Buffaloes are the preferred milch animals in the mountains. Cows are mainly kept to produce bullocks. Buffaloes are also given preference in the feeding of high-quality feed items particularly in the sedentary system of animal keeping. Bullocks are provided special feeding care during ploughing season and also on special occasions when importance of *goudhan* (the cattle wealth) is celebrated.

Livestock size and composition are dictated by ecological and socioeconomic realities of the region. Cattle size is determined mainly by draught requirement. People's reverential attitude (or sentiments) towards cattle is not a factor affecting livestock population composition as sometimes misconceived. It becomes clear from the fact that over last many decades buffaloes' and goats' numbers have been increasing while those of cattle are constant or decreasing (Partap and Singh 2002; Singh and Tulachan 2002).

The State has a variety of livestock – cattle, buffaloes, goats, sheep, horses, ponies, mules, and pigs – numbering 4608656, according to the 1997 Livestock Population (Table 3.1). There are 955012 poultry fowl and 17257 other poultry birds in the State. Among these animals, cattle constitute the highest percentage of population (43%), followed by buffaloes (24%), goats (23%), sheep (7%), and horses, mules, pigs and others (1% each) (Fig. 3.1).

Table 3.1 Population of Different Species of Livestock in Uttranchal

Cattle	2030856
Buffaloes	1094295
Sheep	310750
Goats	1085700
Horses, Mules	23560
Pigs	31551
Others	31944

Source: Kurup, M.P.G. 2002.

As manurers, exploiters of wastes, sources of power, risk cushions, transporters and sources of raw materials (milk, meat, wool etc.), the livestock benefit the mountain farmers directly. Furthermore, livestock play an important role in the cultural identity of mountain people

Most of the cattle in Uttaranchal are small and non-descript. Crossbred population of cattle accounts for five percent of the total cattle population. Buffaloes population is largely composed of the grades of Murrah from the neighbouring states. Sheep are mostly concentrated in the upper reaches of the Himalayas. Goats are widely distributed in all districts. Pig population in Uttaranchal is tiny and is only concentrated in the plain and foothill areas of the State around Hardwar, Udham Singh Nagar and Dehradun. Horses, mules and donkeys are the carry pack animals. Over 60 percent of the poultry birds are desi being reared in the backyard system.

Cattle bullocks are the sole source of draught power in the mountain areas. The plain agriculture in the districts of Dehradun, Udham Singh Nagar and Hardwar, however, is also supported by tractors.

The trend in livestock population in Uttaranchal between 1993 and 1997 reveals a sharp decline in the population of cattle and sheep and a marginal decrease in the population of goats. However, population of other species of livestock has decreased over this period (Fig. 3.2).

The species wise contribution to the asset value and the unit value are presented in Table 3.2 and Fig.3.3. More than half the asset value of the livestock is on account of the most important milch animals in the State. Adult female buffalo and crossbred clearly indicate the primacy of milch animals in the rural livelihood system. Working males make up the next most important group, accounting for over 30 percent of the total asset value.

Contribution of livestock sector to the Gross State Domestic Product in 1999-2000 accounted for 7.51 percent (contribution of agriculture along with livestock being 37.02 percent) at current prices. Total output value and product wise contribution are presented in Table 3.3. Milk accounted for as much as 77 percent of the total output value. Meat value accounted only some 6 percent, less than half of dung (13 percent). Dung as a valuable output of livestock industry, unfortunately, is ignored. Traditional farmers, especially the women, nevertheless, recognise the value of dung.

Fig. 3.2: Trends in Livestock Population Change between 1993-1997

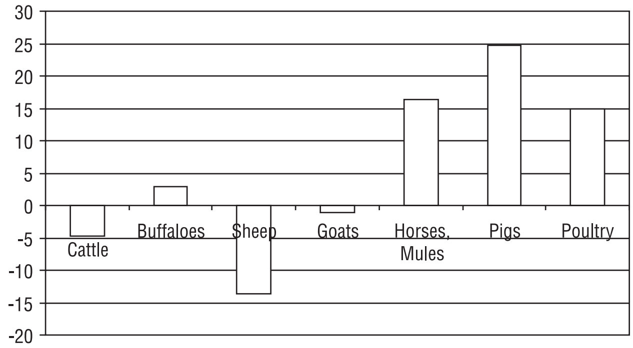


Fig 3.1: Livestock Composition in Uttaranchal

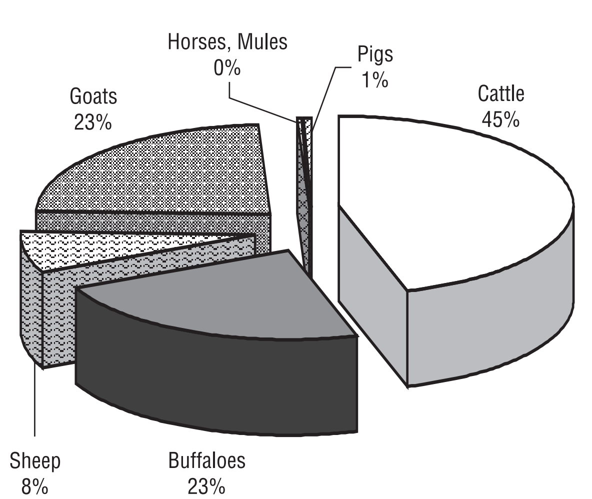


Fig. 3.3: Asset Value (%) of Livestock in Uttaranchal

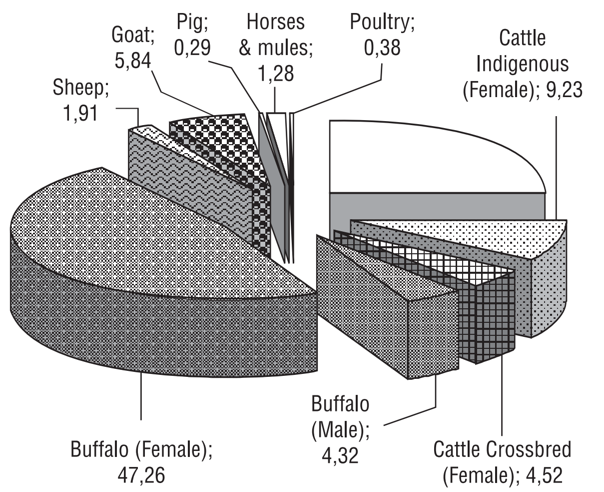


Table 3.2: Asset Value of Livestock in Uttaranchal

S. No.	Species	Numbers	Unit Value (Rs.)	Total Value Rs. Mln	Percent
1	Cattle Indigenous & Crossbred (Male)				
A	Adult Male	734177	3780.00		
B	Young Stock Male (Adult Equivalent)	125076	3780.00		
	Total	859253	3780.00	3247.98	24.97
2	Cattle (Female)				
A	Indigenous Adult	625000	1500.00		
B	Indigenous Young Stock (Adult Equivalent)	175068	1500.00		
	Total	800068	1500.00	1200.00	9.23
3	Cattle (Female)				
A	Adult Crossbred	46301	10000.00		
B	Young Stock Crossbred (Adult Equivalent)	12546	10000.00		
	Total	58847	10000.00	588.47	4.52
4	Buffalo Male				
A	Adult Male	61487	3780.00		
B	Young Stock Male (Adult Equivalent)	87317	3780.00		
	Total	148804	3780.00	562.48	4.32
5	Buffalo Female				
A	Adult Female	655071	8000.00		
	Young Stock Female (Adult Equivalent)	113321	8000.00		
	Total	768392	8000.00	6147.14	47.26
6	Sheep	310705	800.00	248.56	1.91
7	Goat	1085700	700.00	760.00	5.84
8	Pig	31551	1200.00	37.86	0.29
9	Horses & Mules	23830	7000.00	166.81	1.28
10	Poultry	972269	50.00	48.81	0.38
	Total			13008.11	100

Notes: 1. Stock increment and Capital Gain not included; 2. Young stock of all age groups equated to 0.5 adult units per head for valuation purposes; 3. Crossbred cattle male valued along with indigenous male as their numbers are very small.

Source: Kurup, M.P.G. 2002. Livestock Sector in Uttaranchal & Integrated Livestock Development Plan. *DASP Uttaranchal*

Farming Situations

Farming systems in the Central Himalayas are spread over a wide range of altitudes and different slope directions. Temperature and humidity in mountain areas greatly vary according to altitude, slope direction, and distance from the snowline or plains. Availability of water for irrigation is also a site factor. Based on these considerations that are vital for agricultural performance, 11 farming situations have been identified in the Central Himalayas (GB Pant University 1989, Singh 1995, 1998b).

Each farming situation is characterised by specific niche, vital for specific botanical composition,

Table 3.3: Livestock Sector Output Value: 2000-2001

S. No.	Details	Unit Price Rs.	Production	Total Value Rs. mln	% to Total
1	Milk		Metric Ton		
1.1	Cow	8.00 per kg	145235	2323.76	
1.2	Buffalo	11.00 per kg	422602	4648.62	
1.3	Goat	7.00 per kg	1600	112.00	
1.4	Total		**0.569	7084.38	77.15
2	Meat		Metric Ton		
2.1	Buffalo	30.00 per kg	1860	55.80	
2.2	Goat	100.00 per kg	3050	305.00	
1.3	Sheep	100.00 per kg	1420	142.00	
2.4	Pig	80.00 per kg	980	78.40	
2.5	Total		7310	581.20	6.33
3.	Dung	200.00 per MT	5.94	1188.00	12.94
4.	Wool	25.00 per kg	**233	5.83	0.06
			Numbers		
5.	Hide: Large Ruminants	500 per unit	69350	34.67	
	Skin: Small Ruminants	60 per unit	402131	24.12	
	Total			58.79	0.72
6.	Eggs	1.50 per unit	84.87 Million Nos	127.30	1.39
7.	Work Output	3 per kWh	45.79 kWh	137.38	1.50
	Total			9182.88	100

*Notes: Output Value at current price; ** Product quantities are study estimates.*

Source: Kurup, M.P.G. 2002. Livestock Sector in Uttaranchal & Integrated Livestock Development Plan. *DASP Uttaranchal*

cropping patterns, cropping systems, and specific activities and products. For example, valleys in the Outer Himalayas are especially used for growing corn and wheat while these flatlands in the Lesser Himalayas are used for rice and wheat cultivation. Irrigation facilities lead to a change in cropping pattern and genetic diversity.

Irrigated valleys are generally used for cultivating fewer crops of high yielding varieties (HYVs). North direction of the slope receives sunlight for shorter duration as compared to the south directional slope, making the former situation much colder than the latter. Hence, direction of the slope also becomes important for cropping patterns in the cropland and

Table 3.4: Farming Situations in the Central Himalayas

Outer Himalayas	1.	Valley, irrigated
	2.	Valley, rainfed
Lesser or Middle Himalayas	3.	Valley, irrigated
	4.	Valley, rainfed
	5.	Mid-hills, north
	6.	Mid-hills, south
	7.	High hills, north
	8.	High hills, south
	9.	High Mountains, north
	10.	High Mountains, south
Greater Himalayas	11.	Alpine pastures

Source: Adapted from GB Pant University (1989) and Singh (1995, 1998)

Table 3.5: Farming Situations in Central Himalayas: Some Basic Features

Situation	Name of Situation	Altitude (m)	Rainfall/ Snowfall	Soil	Principal crops	Forest type	Cultivated area (approx. %)
1	Valley, Irrigated	600-1000	3000-4000	Alluvial sandy loam	Rice, wheat, maize, onion, chillies, etc.	*Shorea robusta*	2
2	Valley, Rainfed	600-1000	3000-4000	Residual sandy loam	Maize, madua, wheat, citrus, mangoes, etc.	*Shorea robusta*	2
3	Valley, Irrigated	600-1200	3000-4000	Colluvial sandy loam	Rice, wheat, onion, chillies, etc.	*Shorea robusta* and *Pinus roxburghii*	10
4	Valley, Rainfed	600-1200	3000-4000	Residual sandy loam	Mandua, rice, wheat, citrus, mangoes, etc.	*Shorea robusta* and *Pinus roxburghii*	6
5	Mid-hills, North	1200-1700	3050-4100	Brown, Rare snowfall	Mandua, jhangora, rice, wheat, peach, plum, apricot, apple, tomato, potato, peas, etc.	*Quercus leucotrichophora*	24
6	Mid hills, South	1200-1700	3050-4100	Sandy loam, silty loam	Rice, wheat, mandua, jhangora, plum, citrus, tomato, etc.	*Quercus leucotrichophora*	36
7	High Hills, North	1700-2500	2000-3000, moderate snowfall	Red to dark black clay loam	Amaranth, mandua, rajma, apple, apricot, pears, walnut, etc., off-season vegetables	*Quercus leucotrichophora, Q. floribunda*	4
8	High Hills, South	2000-3000, moderate snowfall	2000-3000, moderate snowfall	Red to dark black clay loam	Amaranth, mandua, rajma, apricot, pears, walnut, etc., off-season vegetables	*Quercus leucotrichophora*	8
9	High Mountains, North	2500-3500	700-1300, High snowfall	Red to dark black clay loam and meadows type	Amaranth, buckwheat, naked barley, potato, apple, apricot, pears	*Q. semecarpifolia*	1
10	High Mountains, South	2500-3500	700-1300, High snowfall	Red to dark black clay loam and meadows type	Amaranth, buckwheat, naked barley, chenopodium, potato, apple, apricot, pears	*Q. semecarpifolia, Alnus nepalensis*	3
11	Alpine pastures	3500 and above	Rainfall scanty, very heavy snowfall	Meadows soils with heavy texture	No crops or trees, Juniper us grasses	*Danthonia cachemyriana*	4

Source: Adapted from GB Pant University (1989).

vegetation type in the forest. Generally sturdy, drought tolerant crops and their different varieties are cultivated on drier and warmer south-directed slopes.

Alpine meadows in the in the Greater Himalayas just adjacent to snowline are used for transhumant pastoralism and for raising some medicinal and aromatic plants and some rare crops, like the naked barley.

Facilities of irrigation transform the farming situation in valleys in favour of monocultures. Biodiversity both at species and genetic level is severely reduced in farming practices under irrigation facilities. Most of the cultivated land in irrigated valleys is occupied by wheat and rice monocultures in summer and winter season respectively. Only a few pockets in the market-linked areas have been transformed into vegetable growing areas. The noticeable scenario in this farming situation is that of treeless terrace bunds that further leads to reduced diversification of agriculture and increased threats of topsoil erosion and landslides, apart from numerous risks for farmers.

The unirrigated valleys essentially depict agroforestry systems, which are ideal ones in most of the cases. The terrace bunds are covered with trees of great economic values. Terraced fields cultivate variety of local cereal crops. Higher degree of genetic diversity contributes to farmers' security.

Most of the agricultural land is concentrated at mid-altitudes. This eco-zone provides the most suitable ecological niche for cultivating most of the food crops in the mountain region. All the cereals, coarse grains and pulses are cultivated in this eco-zone in different seasons. This farming situation forms a cropping system dominated by millets and pulses. Cropland is an agroforestry system. Fodder trees – mostly the *bhimal* (*Grewia optiva*) trees – are often found on the bunds of the fields. South-oriented slope, due to more exposure to solar radiation, is especially suitable for farming. About 36 percent of the total cultivated area in the Central Himalayas lies in this zone. Most of the foodgrain produced in the mountain areas obviously comes from this farming situation.

High hills, occupying some 12 percent area under cultivated land, are the most suitable farming situation for pseudo cereals, like amaranth and buckwheat, and kidney bean. This zone also provides the ideal niche for temperate fruits, like apple, apricot, plum, and peach. Some areas in the Central Himalayas have been transformed into fruit belts with apple as the dominant fruit. Vegetables – often known as off-season vegetables (in the context of the plains) are also raised in this farming situation. Fruits and vegetables are often grown together.

High Mountains occupy about four percent area under cultivated crops and fruit trees. This farming situation is an ideal ecological niche for amaranth, buckwheat, naked barley, chenopodium, potato, apple, apricot, and pears. Only one crop is taken in the whole year. Being amidst plenty of forests and green pastures in the surrounding areas, the farming system is dominated by livestock with ovine species – goat and sheep – as the main animals reared by the transhumant people inhabiting these areas.

Alpine pastures cover about four percent area in the Central Himalayas. Almost devoid of any tree cover, the alpine meadows harbour rare plant species and form a unique ecosystem on Earth. The meadows remain covered by snow for about six months in a year. Especially rich variety of herbaceous plants found in the alpine pastures serve as excellent fodder for livestock of the tribal and transhumant communities in the mountains.

Cropping Systems

Diverse cropping systems have been designed by farmers in tune with specific micro-ecological niches suiting to the cultivation of specific crops and crop combinations. Mountain farmers thus have developed four major cropping systems:

i) Homestead-based cropping system or kitchen garden;
ii) Irrigated land cropping system;
iii) Rainfed or upland cropping system; and
iv) Summer camp cropping system

The homestead-based cropping system or kitchen garden is an essential feature in rural mountain areas. Seasonal vegetables are grown near homestead. Almost all creeper type vegetable species would appear in this cropping system. Some fruit trees and ornamental plants would also be found. Biodegradable kitchen wastes, hearth ash, and water drained from the household are the main inputs used in the homestead-based cropping system. Produce of this cropping system is entirely for home consumption.

The irrigated cropping system in river valleys supports the water guzzling crops. Wheat and rice are the two main crops in this cropping system. HYVs of these crops that demand large amount of water are often cultivated in this system. In some pockets vegetables relying on irrigation are also cultivated for market purpose. This cropping system would not give any important place for tree farming and is less diversified. This is the cropping system that has witnessed enormous genetic transformation in mountain areas. External inputs – mainly the HYVs, chemical fertilizers and occasionally the pesticides – would be employed in this cropping system, for generally monocultures are raised here, which are more vulnerable and risk prone.

The rainfed cropping system in upland areas is the part of mainstream mountain farming. This harbours

Table 3.6: Wild Relatives of Economic Plants in the Indian Himalayan Region

A. North-West and Northern Himalayas	
Cereals and Millets	*Aegilops tauschii, Avena barbeata, A. fatua var. fatua, A. ludoviciana, Digitaria sanguinalis, Elymus dalutricus, E. dasystachys, E. nutans, E. distans, E. orientale, Hordeum glaucum, H. spontaneum, H. turkestanicum, Penisetum orientale.*
Legumes	*Cicer microphyllum, Lathyrus aphaca, Moghania vestita, mucuna capitata, Trigonella emodi, Vigna capensis, V. radiata var. sublobata, V. umbellata.*
Fruits	*Elaeagnus hortensis, Ficus palmate, fragaria indica, Morus spp., Prunus acuminata, P. cerasoides, P. cornuta, P. napalensis, P. prostrata, P. tomentasa, Pyrus buccata, P. communis, P. kumaoni, P. pashia, Ribes glaciale, R. nigrum, Rubus ellipticus, R.fruticosus, R. lanatus, R. lasiocarpus, R. molluccanus, Zizyphus vulgaris.*
Vegetables	*Abelmoschus manihot (tetraphyllus forms), cucumis hardwickii, C. callous, Luffa echinata, L. graveolens, Solanum incanum, S. indicum, Trichosanthes multiloba, T. himalensis.*
Oilseeds	*Lapidium capitatum, L. latifolium, L. draba, L. ruderale.*
Fibres	*Linum perenne.*
Spices and Condiments	*Allium rubellum, A. schoenoprasum, A. tuberosum and other species, Carum bulbocastinum.*
Miscellaneous	*Saccharum filifolium, Miscanthus nepalensis.*
B. Eastern and North-Eastern Himalayas	
Cereals and Millets	*Digitaria cruciata, Hordeum agricrithon.*
Legumes	*Atylosia barbata, A. scarabaeoides, A. villosa, Canavalia ensiformis, Mucuna bractearata, vigna umbellate, V. radiata var. sublobata, V. pilosa.*
Fruits	*Fragaria indica, Morus spp., Myrica esculenta, Prunus acuminata, P. cornuta, P. jenkinsii, P.nepalensis, Pyrus pashia, Ribes glaciale, Rubus lineatus, R. ellipticus, R. lasiocarpus, R. molluccanus, R. reticulates, Citrus assamensis, C. ichangensis, C. indica, D. hookeriana, Eriobotya angustifolia, Mangifera sylvatica, Musa balbisiana complex, M. manii, M. nagensium, M. sikkimensis, M. supreba, M. velutina.*
Vegetables	*Abelmoschus manihot (pungens forms), Luffa graveolens, Neoluffa sikkimensis, Cucumis hystrix, C. callosus, Momordica dioica, M. cochinchinesis, M. macrophyllata, M. subangulata, Trichosanthes cucumerina, T. dioica, T. dioaelosperma, T. khasiana, T. ovata, T. trumcata, Solanum indicum and tubertypes, Allocasia macrorhiza, Amorphophallus bulbifer, Colocasia esculenta, Dioscorea alata, moghania vestica, Vigna capensis.*
Oilseeds	*Brassica trilocularis types.*
Fibres	*Gossypium aboreum (primitive types).*
Spices and Condiments	*Allium tuberosum, A. sublobatum, Curcuma zedoaria, Alpinia galanga, A. speciosa, Amomum aromaticum, Cucuma amoda, Piper peepuloides.*
Miscellaneous	*Saccharum langisetosum, S. sikkimensis, S. ravennae, Erianchus spp., Miscanthus nudipus, M. nepalensis, M. taylorii, Naranga fallax, Camellia spp.*

Source: Arora and Nayar (1984)

all the millets, pulses, pseudo cereals, and local varieties of wheat and rice. Millets (finger millet and barnyard millets) and pulses, always intermixed, are raised in this cropping system. The *Baranaaja* is the most important cropping pattern in the rainfed or unirrigated cropping system. Tree farming is essentially integrated with food crops. This cropping system is a rich repository of mountain agro-biodiversity. Only the internal organic inputs are used. The cropping system has no dependence on market system. The produce, which is of very high nutritive value, is almost entirely for home consumption.

The summer camp cropping system is maintained on high altitudes mostly amidst oak forests taking full advantage of its organic humus and moisture regime. Pseudo cereals (amaranth and buckwheat) and beans (mainly the kidney beans) are the main crops of the system. Only one crop is taken in a year.

Genetic Resource Diversity

An enormous diversity of plants, both cultivated and wild, offering edible products, is one of the most outstanding features of the mountain flora. Farmers' interactions with plants, animals and their environment and their protection, selection, domestication and cultivation of native plants, introducing and improving exotic plants have all given rise to an enormous genetic diversity in the mountain environments.

The crop plant genetic resources of the world can be more or less assigned to the specific centres of diversity identified by Vavilov (1951) on the basis of varietal diversity, homologous variation, endemism, dominant allele frequencies, and disease resistance (Khoshoo 1996).

In India, there are eight sub-centres, namely, i) Western Himalayas, ii) Eastern Himalayas, iii) North Eastern Region, iv) Gangetic Plains, v) Indus Plains, vi) Western Ghats, vii) Eastern Ghats, and viii) Andaman and Nicobar (Arora and Nayar 1984). The first three of these fall in the Himalayan belt. There are around 399 species of wild relatives of crop plants belonging to 90 genera in the Western, Eastern, and North-Eastern Himalayas.

The Himalayan Region has especially been the source of several cereals, pulses, fruits, oil-yielding plants, spices, tuberous vegetables, and sugar-yielding plants and their close relatives that number 155 (Arora and Nayar 1984). A list of wild relatives of economic plants in the Himalayan Region is given in Table 3.6.

The responses of mountain plants to their environment are due to a complex mixture of genetic and environmental influences. There is evidence that some mountain plants have evolved in response to their particular altitudinal environment. In comparison to their lowland counterparts, the mountain plants have increased ability to fix CO_2 from lower than sea-level concentrations, use high irradiance levels more efficiently, photosynthesise and grow at lower temperatures and have intrinsically lower growth rates (Friend and Woodward 1990). This plasticity evolved in the mountain plants puts them under rare species. Mountain food crops should, therefore, be regarded as the rare crops. Such a wonderful and valuable diversity in food crops is virtually not witnessed anywhere in the world.

Intra-species diversity in food crops again is of great value. Each crop would have an impressive number of varieties. Each variety is adapted to specific environmental conditions and carries unique economic, social, cultural, and ecological values.

There are many breeds of all classes of livestock in mountain areas, which are highly adapted to the harsh climate and difficult terrain. Cattle especially have very broad genetic variation. Cattle breeds have superb traits and are a boon for mountains' agro-economy. Genetic diversity amongst domestic animals is enormous. However, most of the local breeds have still not been fully described.

4

Conventional Technologies and Agricultural Transformation

A wrong attitude to nature
Implies somewhere a wrong attitude to God
And the consequence is an inevitable doom.

– T.S. Eliot

Our meddling intellect
Misshapes the beauteous forms of things –
We murder to dissect.

– Wordsworth

Since the beginning of agriculture, nations have struggled to monopolise certain plants of commercial importance. This struggle was most obvious and at its greatest height during the colonial era of the last century. Then, new scientific tools and a network of botanical gardens brought about the transformation of world agriculture. Today, the struggle to monopolise specific genes in the development of agriculture is leading to the development of other scientific tools and institutions: chief among them, the gene bank and the International Agricultural Research Centres. Now, as in the last century, scientists are largely pawns in a much larger scheme.

– Pat Roy Mooney (1983)

Due to cultural and mobility constraints, women are largely excluded from the world of commercialisation.

– Manjari Mehta (1990)

I tell the young people up in my orchard again and again not to try to imitate me, and it really angers me if there is someone who does not take this advice to heart. I ask, instead, that they simply live in nature and apply themselves to their daily work. No, there is nothing special about me, but what I have glimpsed is vastly important.

– Masanobu Fukuoka (1984)

When people are liberated from "development" that purely aims at growth then an effective sustainable life style based on traditional subsistence economy can survive and hence an ecologically balanced peaceful world and future can be ensured for humankind.

– Kabita Chakma (1994)

If we were logical, the future would be bleak indeed. But we are more than logical. We are human beings, and we have faith, and we have hope, and we can work.

– Jacques Cousteau

Modern scientists look at nature from an atomistic, materialistic point of view. We focus on discrete material entities – atoms, stones, plants, planets, etc. We entirely fail to see the dynamic system in which they are embedded, which is why our technology (e.g., the 'storage bin' model of crop production) has proved to be so clumsy and disruptive of nature.

– M.G. Jackson (2002)

Towards Intensive Use of External Inputs

Transformation in agriculture has led to alter value system in rural areas. Mechanisation has been central to the Green Revolution technology. It gives no value to draught animals for use in agriculture. Although farmers in some highly patronised areas have widely adopted new high yielding varieties (HYVs) irrespective of farm size and tenure, factors such as soil quality, access to irrigation water, and other biophysical and agro-climatic conditions have been formidable barriers to their adoption. The Green Revolution technology has been woven around intensive use of external inputs. It is totally insensitive towards socioeconomic and ecosystem realities and is indifferent for different areas or regions.

Impressive economic contributions of the Green Revolution to large farms in the Terai area of the Central Himalayas, to a great extent, are attributable to massive amounts of fossil fuel energy used in farm machines. The upper limits of production under the Green Revolution package of practices, however, have overreached. Having experienced the bitter taste of the produce of Green Revolution, ecological vulnerability and growing risks of crop damages, environmental pollution and health hazards, and unscrupulous invasion of market forces controlled by multinational corporations, now even the 'prosperous' farmers of the Terai area have begun to choose the different paths of farming.

Farmers of almost all categories in the mountains have to operate all farming activities using the inputs produced within their own agro-ecosystems. The conventional agriculture, nevertheless, is making all efforts to make inroads in the favourable pockets to bring in transformation to absorb high quantities of external inputs. Valley areas equipped with the irrigation facilities are such pockets where Green Revolution has already captured its roots. A network of public sector agricultural research and extension is involved in implementing external input-inducing programmes in forestry, horticulture, crop and animal husbandry, fisheries, etc.

Inherent Physical Constraints

Fragility of landmass, topographic variations, problem soils, and climatic extremes are the major inherent physical constraints to mountain agriculture. Mountain agriculture has to be maintained within these constraints. Effects of these constraints have been mentioned in Table 4.1.

Himalayan mountains are the youngest geological creation on Earth. They are still stabilizing themselves. They are extremely fragile and prone to large-scale damages. Any untoward change, even of small measure, brought in the Himalayan landscape often leads to an irreversible damage. It is difficult to arrest, or even to minimize, the impact of fragility. Every human activity, including farming, therefore, will be at the cost of damage caused by the inherent fragility factor. Owing to this, a limitation on resource use intensity is imposed. Carrying capacity of natural resources is also often low. However, with greater accuracy and consciousness, we can attempt to minimize the impact of any change in the mountain landscape.

Topographic variations with steepness of slopes and high degree of inaccessibility make mountain farming systems difficult to manage. Variations in altitudes and slope orientation influence weather conditions and microclimate in the region. Seasonal periodic hazards (such as catastrophic landslides, river cutting, cloud burst, avalanches, snowfall, etc.) as a result of complex inherent factors would be other additives in making the farming management difficult

Table 4.1: Inherent Physical Constraints and their Implications on Mountain Farming

Main Constraints	Implications on Mountain Farming
Fragility of Landmass Susceptibility to landscape/ ecological impairment Limited resource use, low carrying capacity	• Excessive soil erosion; • Catastrophic landslides; • Restricted flow of basic inputs (bedding, fodder, fuelwood, etc.) from CPRs and cropland; • Restrictions on bringing desired area of land under plough; • Inability to use mainstream patterns; • Reduced range of options; • High risks to life.
Topographic Variations Difficult and undulated terrain, limited accessibility, remoteness, slope steepness	• Fragmented and scattered holdings; • Restricted mobility; • Difficult management of resources; • Wastage of human and animal labour and time; • Decrease in yield potential; • Restricted external/ market linkages.
Problem Soils Presence of stones, low pH, shallow, low water holding capacity	• Vulnerability to excessive erosion by air and water • Limited productivity of crops; • Reduced options for diversification of cropping/ agricultural activities.
Climatic Extremities Erratic rains, snowfall, hailstorms, strong winds, seasonal hazards.	• Limited mobility; • Communication gap within the communities; • Increased soil erosion and landslides; • Limited production options; • Difficult management of resources; • Greater chances of crop damage; • High risks to human and animal health.

Source: Adapted from Singh (1998a).

and challenging. Fragmented and scattered holdings – a manifest of the mountain topography – further add to the woes of mountain farming.

Himalayan soils by and large are problem soils. Low water holding capacity, high proportion of gravel/ chert, low pH, nutrient deficiencies, variation in texture, colour, and depth, vulnerability to erosion, etc. are the physico-chemical characters which make mountain soils extremely diverse, but, at the same, problematic also. This situation leads to extreme fluctuations in the productivity of crops.

Climatic extremes (erratic rains, hail storms, snowfall, strong wind currents, seasonal periodic hazards, temperature fluctuations, etc.) form yet other constraints. This situation severely affects the performance of agriculture in mountain areas (Table 4.1).

The Unsustainability Indicators

Unsustainability indicators of mountain agriculture that have emerged over the past 50 years are listed in Table 4.2. An incredibly high increase in landslides, soil erosion, appearance of rocks/ stones in cultivated land, and river cutting and further abandonment of farming due to decreased fertility and landslides are the common visible negative changes

Table 4.2: Unsustainability Indicators in Mountain Agriculture (Time Frame: 40-50 Years)

Indicators	Range of Change in Percentage
I. RESOURCE BASE	
Increased landslides	(+) 50-300
Increased soil erosion	(+) 20-200
River cutting	(+) 50-150
Stones/ rocks on cultivated land	(+) 20-100
Abandonment of land due to low fertility	(+) 20-40
Abandonment of land due to landslides	(+) 10-40
Decreased size of livestock holding	(-) 63-80
Reduced proportion of cattle in herd	(-) 73-84
Reduced number of draught animals per farm	(-) 68-40
Increased proportion of crossbred cattle	(+) 0-6
Reduced proportion of draught animals in the herd	(-) 13-56
Decreased area under forests/ pastures	(-) 10-40
Reduced availability of grazing area due to:	
(a) Construction works in the Himalayas	(-) 2-6
(b) Invasion of exotic plants in lower hills	(-) 20-80
(c) Conversion into cultivated land	(-) 10-40
II. RESOURCE MANAGEMENT	
Increased use of pine needles as bedding material	(+) 50-100
Increased use of external inputs	(+) 5-200
Use of weeds as bedding material	(+) 0-5
Increased use of CPRs for non-pastoral activities	10-60
Replacement of social sanctions of CPR's use by legal measures	Medium – High
Reduced fallow periods for use of PPRs as CPRs	Six months – Few days
III. PRODUCTION FLOWS	
Reduced foodgrain productivity:	
Rice	(-) 50-69
Wheat	(-) 58-66
Finger millet	(-) 50-63
Barley	(-) 58-66
Barnyard millet	(-) 45-56
Amaranth	(-) 67-75
Pulses	(-) 33-50
Reduced dung production	(-) 63-80
Reduced manure application in cropland	(-) 60-75
Reduced production of crop by-products (straws)	(-) 33-70
Decreased level of concentrate feeds	(-) 73-84
Reduced milk productivity per head per day of:	
Cow	(-) 33-50
Buffalo	(-) 50-67
Higher intensity of plough hiring	(+) 0-40
Reduced intensity of plough sharing	(-) 7-30
Decreased availability of suitable woods for tools and implements	Low – High
Increased time spent in fodder collection from CPRs	(+) 200-400
Increased dependence on human labour for agricultural work	(+) 100-200
Fodder supplies from:	
Common lands	(-) 50-75
Private land	(+) 100-150
Increased bullock work with restless period per day	(+) 67-167

Source: Singh (1992, 1998a)

that have posed a threat to mountain agriculture over the years.

Decreased livestock holding size (number of livestock per family), reduced proportion of cattle and bullocks in overall herd and draught animals per household, added up with decreased area under forests/ pastures which serve as potential source of livestock fodder, and consequent reduction in the availability of grazing land due to some obvious reasons, such as construction activities specially in the alpine zone, colonization of exotic plants (*Lantana* spp. and *Parthenium* spp.) at lower altitudes in the Shivalik and the foothills of the Himalayas and conversion of forest areas into cultivated land almost everywhere are the resource-related unsustainability indicators.

On the resource management front, there is now increased use in the animal sheds of pine needles with poor biodegradability instead of highly biodegradable leaves of oaks, rhododendron etc. which earlier used to enrich manure quality for subsequent soil fertility. There has been a very high increase in the use of external inputs, particularly the chemical fertilizers in the transformed valleys and fruit and vegetable belts at higher altitudes.

Promotion of White Revolution technology involving intensive crossbreeding of local cows with exotic bulls mainly through artificial insemination, which is not conducive to mountain areas' specificities to be discussed soon, should also be regarded as a negative change.

In recent years, some emphasis by public sector has been laid on monocultures of some food grain crops (such as white-seeded soybean) and trees (such as *Eucalyptus*, *Poplar*, silver oak), which do no provide fodder and also replace fodder-providing plants. Increased use of CPRs for non-pastoral activities and replacement of social sanctions of their use by legal measures are the negative indicators reducing the options for development of CPRs and consequently of livestock resources. Few years ago, a portion of arable land used to be left fallow for about six months in a year.

During fallow period the private land used to function as a CPR on which livestock could freely graze. Now, due to reduced fallow periods, especially in the highly transformed areas, livestock owners have no facility to use private property resources (PPRs) as CPRs.

Emphasis on HYVs generally characterised by narrow straw-grain ratio in place of native plant varieties with reverse characteristic (i.e., wider straw-grain ratio) further creates conditions for reduced supply of fodder from cultivated land.

Now looking at the production flow-patterns, one finds considerable reduction in dung production, manure application in cultivated land, straw production, concentrate feeds and milk productivity. Decreased flow of foodgrains from the cultivated land is an obvious result and one of the most talked about negative changes in mountain agriculture. Decreased availability of suitable wood for agricultural tools and implements is the other noticeable negative change.

Ecological degradation and reduction in the area of commons leads to decreased supply of fodder from these lands, while steep increase in fodder supplies from private land is evident and these are, obviously, negative indicators. Judging from the over-strain on the work bullocks due to continuous and restless work throughout the day with interrupted fodder and water supplies and required care, should also be treated as a negative indicator (increase in working days and thus in total work hours with adequate feeding and care would be a positive indicator). Decreased number in draught animals also leads to increased dependence on human labour for land preparation often resulting into drudgery on women farmers. Higher intensity of plough-hiring and reduced intensity of plough sharing – symptomatic of reduced social cohesion – should also be regarded the negative indicators. The negative indicators portraying the dynamism of unsustainability are, of course, not independent. Changes at one level are bound to induce changes at other levels.

The Predominant Scenarios

In large areas of the Central Himalayas predominant traditional – by and large subsistence – agriculture is evident. Majority of mountain population overwhelmingly subsists on and engaged in traditional agriculture. High degree of inaccessibility or isolation creates conditions for traditional agricultural management. Higher the degree of inaccessibility the brighter the chances of traditional management. In isolated areas, farmers generally tend to be self-sufficient. Natural diversity existing in the traditional systems, as gauged by the analysis of the farming systems, farming situations, cropping systems, plant and animal species, and variability within species, has been and is being utilized by traditional farmers for their sustenance and for developing diverse food production and livelihood systems (Singh 1995).

Production activities in the traditional areas are diversified to a high degree. There are two types of farming systems: (i) cereal crop-dominated, and (ii) livestock-dominated farming system. Cereal crop-dominant system prevails in the Shivalik and foothill zones as well as in the Middle mountains. In general, wheat/ paddy-based cropping patterns predominate on irrigated land, maize-based on rainfed in the hills, millet-based on the upland mid-altitudes and pseudo cereal-based on high altitude summer camp lands in the middle mountains.

Croplands in the foothills/ valleys are largely irrigated. In the Middle Himalayas it is largely rainfed and in the Greater Himalayas, it is totally rainfed. Whereas in the foothill zone both traditional and high-yielding varieties of crops are cultivated simultaneously, in the traditional areas of middle mountains crops mostly include traditional varieties. The herd is cattle dominated. DAP, the dominant component of the animate energy system, is managed through independent, shared, hired-in and hired-out channels of draught animal use system. The linkages with the market system are poor (Singh 1998a).

The livestock-dominated farming system managed by transhumant pastoralists residing for half a year in the Greater Himalayan zone, includes the herd dominated by ovine species, specially the sheep. Average livestock holding size is very large and high incidence of bullock sharing in the energy use system is observed. Alpine meadows are an important component of the farming system and they are the major source of livestock feeds for about six months in a year. Linkages of this system with the external market are also poor, almost non-existent. The livestock based farming system, in fact, is still in a primitive stage of development (Singh 1998a).

The Current Scenarios

Mountain farmers use scarce land resources more efficiently for gainful employment and increased incomes. The cropping approach is based on cash crop farming and inter-systemic linkages, new forms of diversification (activities), using inputs from science and technology, and building sound upland-lowland linkages (Partap 1995, Partap and Singh 2002). This represents the commercialization of mountain agriculture.

Mountain environments provide suitable niches for special activities and products, and harnessing these niches with appropriate location-specific farming activities provides comparative advantage over the plains. The diverse agro-ecological conditions or farming situations prevailing in the mountains form suitable ecological niches for horticulture, floriculture, spice cultivation, and medicinal and aromatic plants.

In the process of agricultural transformation, it is the horticulture that has occupied central place. In the lower fertile valleys equipped with irrigation facilities and well linked with market, vegetable-based transformation has taken place. In some areas at high-altitudes, particularly between 1800 m and 2500 m, fruit tree based transformation has captured the core of the transformation processes. In selected pockets of high altitude areas, development of apple orchards is a significant change in mountain agriculture. With high moisture regime, this area also provides an appropriate niche for the off-season vegetable farming. Generally apple cultivation and off-season vegetable cultivation go side by side. In lower valleys, change in genetic composition in cereal crops is a common transformation scenario (Singh 1998a).

Generally, the transformation in any area is not uniform and 100 percent. A number of cropping systems both representing traditional as well as transformed farming are maintained in the same agro-ecological zone and thus transformation actually is the result of diversified farming activities. This mix of cropping practices, in addition to providing on-farm and off-farm employment opportunities and raising economic standard of the households, enhances security of the farmers depending on the farming system. How it affects the overall biodiversity, especially the agro-biodiversity of the farming system, and specific gender role in mountain agriculture is still to be discussed.

One thing is common to the development of transformed systems mentioned above. They are all energy-intensive. In addition to the use of low to high external inputs, the transformed systems require high amount of animate energy. In mountain areas, owing to specific circumstances, fossil fuel-powered machines have not become the part of transformation processes as would be expected in the plain areas. Draught animals and human muscle energy form the only source of energy system to keep the transformation of the farming system going (Singh 1998a, Partap and Singh 2002).

Technological Factors

The conventional agricultural development strategies built around the Green Revolution technology completely ignore mountain specificities. Small and scattered landholding size, high degree of inaccessibility, limited irrigation, farmers' inability to purchase costly chemical inputs, etc. are some factors resisting the spread of the imported agro-technology indiscriminately in all the areas.

HYVs have vanished local seeds from many parts of the mountains. Introduced white-seeded soybeans have resulted into reduced area under the millets, particularly the *baranaaja* culture. The conventional agro-technology's only target is higher yields obtainable through employment of external inputs. Socio-cultural and ecological costs of this technology are virtually ignored.

Crossbreeding of indigenous breeds of cattle by European bulls has been the standard White Revolution technology for improving livestock production in mountain areas as also elsewhere in the Third World. This technology, despite huge public sector investment, has been met with little, rather no, success thanks to the non-participation by local people in this programme. The people have dismissed this programme on logical grounds.

In the hills and mountains, the crossbreeding of indigenous cattle has been largely discarded by the farmers. In the context of mountain areas, the White Revolution technology can be questioned on the following grounds:

- The production of crossbreds cannot be sustained without adequate supply of feed items, like cultivated leguminous fodder and concentrates (the cakes and the foodgrains). If limited cultivated land is spared for livestock production (for raising leguminous fodder) and if a large proportion of foodgrains goes to the animals (to meet their demand for concentrates), then animals would be in direct competition with human beings.
- Leguminous fodder crops grow well in irrigated land. In the mountains of Central Himalayas only about 10 percent of the arable land is under irrigation. If a sizable area of this land is put under fodder cultivation, it might further aggravate the problem of family food supply in an area which is already food-deficit and imports large quantities of foodgrains from the plains. In subsistence farming situation, setting apart a part of fertile land for the purposes other than food production for family is very unlikely.
- Native cattle can eat considerably more of the poor quality roughages than the exotic cattle breeds because the gut content of the local cattle amounts to 33 percent of the body weight, far larger than that of the exotic cattle in which the gut content amounts to only 20 percent of the body weight. Indigenous breeds convert the roughages supplemented with some quantities of green fodder (grasses and tree leaves in the mountains) more efficiently in comparison to their crossbred counterparts. The native cattle can sustain and produce to some extent by subsisting on poor quality roughages of crop residues on which the exotic ones cannot even survive properly.
- Crossbreds are more prone to diseases, external parasites' attacks and weather extremes while the farmers in the mountains prefer to keep the type of breeds which are hardy and adapted to local environment and feed resources. The exotics cannot cover long distances, negotiate with rugged, narrow and stony paths and graze on steep mountain slopes, but the local cattle possess all such qualities.
- Crossbreeding as such is a very expensive technology of livestock development. This not only compels the livestock owners to depend on market system for the purchase of essential feed items – cakes, brans, mineral mixture, vitamins, additives etc. – but also requires a whole veterinary network to take care the health aspects and manage breeding programmes. The indigenous livestock, on the other hand, consume the feeds which are produced within the system.
- The local cattle consume biomass of forests and grazing lands and transfer its nutrients to the cultivated land, eat crop residues and recycle the nutrients in the same land on which they grow. The linkages of local cattle with other farming system components are stronger compared to the exotics or crossbreds whose linkages especially with the common property resources are non-existent or are very weak.
- The crossbreeding policy does not take into account the environment in which the animals have to live and produce. In mountain areas,

- like in the developing countries, the environment cannot usually be controlled. As the animals have many functions here, diversity has survival value. Moreover animals selected on the basis of homogeneity do not fare well here as they ought to do under the controlled environmental conditions as in the developed countries.
- Energetic efficiency of crossbred dairy cows under specific mountain conditions is very low (Singh 1993).

The state and quality of forests – the largest component of a mountain farming system – has further been worsened ever since the commercial forestry trends were introduced in the mountains. The conventional forestry emphasizes monoculture forests – single storey forests with thin even-aged stands of trees, especially the conifers or quick-growing broad leaf exotic trees of high market value – and the vital ecological services provided by the forests are hardly reflected in the official programmes.

The commercial forestry is gradually giving way to gradual disappearance of climax forest communities. The natural climax phyto communities are so crucial for soil and water conservation, biodiversity conservation, and maintaining favourable climatic conditions, and at the same time, for providing more amount of useful biomass per unit of land ensuring higher productivity of cropland and livestock on sustained basis. All the coniferous and exotic trees, on the other hand, do not fulfil local people's daily requirements of fodder, fruits, fibre, and fertilizers. Moreover, monocultures of trees introduce and further aggravate ecological vulnerability in the entire ecosystem and these trees play less, and sometime negative, role in conserving basic natural resources, like soil and water and biodiversity.

Institutional Factors

Apart from India's leading agricultural University, Development Officers of the Government departments at district and Development Block levels and village Panchayat bodies at village level, there are dozens of research stations and institutes currently active in research, training, and extension programmes in the State of Uttaranchal. There are too many non-government organizations (NGOs) many of which are also active in research and development in rural mountain areas. There are numerous committees at all levels, farmers' clubs, plant protection teams, moving soil testing laboratories, apple scab controlling teams, and what not? These institutions and organizations have mushroomed in the mountains ever since the development of the Himalayan region assumed priority in national and international agendas.

Looking at such a framework, one would be easily led to imagine that all problems related to mountain agriculture might have been solved by now. But, indeed, they have not been. In fact, as the institutional intervention is strengthening, crises in the mountains are deepening. Most of the corporate-funded projects in the mountains have become objects of bitter criticism by the local people.

In reality, none of the institutional programmes addresses the real issues facing the mountains. The R & D organizations excel only in the seductive language and try to prove that farmers are backward and ignorant of farm cultures and that their traditional technologies are outdated. These organizations merely act as pawns of the multinational corporations by opening new channels for large-scale consumption of their agro-chemicals. Talk to agricultural scientists working in the mountains and it will soon be realized that majority of them do not know about the specificities of the system they are working with. Institutional intervention in fact is a severe blow to the pristine biodiversity-laden mountain agriculture and to farmers' foolproof technologies.

Changing Gender Dimensions

Gender dimensions are changing in transformed agriculture everywhere. Male's role in this new system is more dominant. Women have further been marginalised. Cash-oriented transformation is essentially linked with market and market is a preserve of males. Cash is generated by putting natural elements in economic cycle. Transformation is increasing the flows of natural resources into economic cycle. This process is at the expense of sustainability which is rooted in natural resources. Managers of the market system, who are the males almost exclusively, accentuate the processes through which natural resource base shrinks and cash-based economy swells. This process leads to a state of unsustainability. This process is dynamic, not static. Climax of unsustainability process – deserts or wastelands (including concrete jungles), anarchy, starvation, and death – is inevitable in due course of time.

Transformation processes clearly reveal gender dichotomy (Table 4.3). Man is the planner, decision-maker and actor in the processes of transformation (and hence, in creating a state of unsustainability). Through institutional linkages, he acquires necessary training and loans from banks, the two ingredients indispensable for transformation. It is always the male who would choose varieties of fruits, vegetables and foodgrains that the research and development institutions recommend. In biodiversity-based traditional agriculture, on the other hand, choosing varieties was a woman's prerogative. Woman's knowledge about agriculture has been holistic and transcendental. Her choosing varieties was in tune with biodiversity enhancement. She deeply understood the linkages between biodiversity and sustainability. Biodiversity in agriculture still reigns wherever women are the main planners, decision-makers and actors. Traditional systems in the Himalayas are the glaring examples.

Agricultural transformation has aggravated women's problems and drudgeries. New agro-techniques are labour-intensive. Women have to get involved in all the manual operations. Cultivation of vegetables

Table 4.3: Transformation Processes and Role of Gender

Transformation Processes/ Agricultural Operations	Fruit-based Horticulture		Vegetable-based Horticulture		HYV cropping	
	Man	Woman	Man	Woman	Man	Woman
Planning and decision making	x		x		x	
Aquiring training	x		x		x	
Loan from bank	x		x		x	
Cash transactions	x		x		x	
Institutional linkages	x		x		x	
Choosing varieties	x		x		x	
Manual preparation of fields		x		x		x
Bullock-aided field preparation	x		x		x	
Manure application		x		x		x
Seed sowing/ Plantation/ Transplantation	x	x	x	x		x
Chemical fertilizer application	x		x		x	x
Irrigation		x		x	x	x
Interculture		x		x		x
Earthing up and weeding		x		x		x
Plant care/ Protection	x	x	x	x	x	x
Fruit picking/ Harvesting		x		x		x
Manual fruit/ vegetable/ foodgrain transportation		x		x		x
Fruit/ vegetable transportation by animals and motor vehicles	x		x			
Sale in the market	x		x			
Threshing						x
Winnowing						x
Seed selection						x
Seed storage						x
Purchase of inputs	x		x		x	
Sale of produce	x		x		x	
Cash earning	x		x			

especially requires many times more hours of manual work which is all accomplished by women farmers. Men get involved in the agricultural operations which are aided by machines or bullocks – ploughing, levelling and puddling, for example – while the others requiring only human energy are women's responsibility. Adding fuel to fire, the on-going transformation processes in mountain agriculture have turned the tasks to be accomplished by women back-breaking.

Transformation processes are gender-insensitive. R & D system always approaches male members of the society to implement its programmes. Training facilities are often provided to men. Cash transactions are men's play. Transformation requires investment and loans etc. Loans are often provided to and accepted by male members. Provision of debt, a must for ensuring transformation processes going on, puts farmers on the path to serfdom. Women generally do not like to fall prey to debt and reduce level of their self-dignity and independence. They would like to rely on their own resources, their own energy, their own skills, their own values.

Women articulate agriculture into life. They would cultivate and produce for their families in the first place. Life-creating and life-sustaining food grains, not the cash, are the real wealth for women. Women would stay away from being cash hungry. They do choose the crops and crop varieties that would sustain their children and enhance their families' happiness. Men, on the contrary, would opt for cash crops or commercial crops that are meant for the non-ecosystem people, the city dwellers, for whom money is a god. One would always find men taking keen interest in sale and purchase commodities. Agricultural transformation, in essence, is a baby of male mind.

Current Mountain Scenario and Women's Perception

Mountain women are not just passive witnesses of the current transforming scenarios in the mountains. They sharply react to it. Mountain women, especially in Uttaranchal, are extra sensitive towards the conservation of their natural resources, for the life's happiness and sustainability is rooted in the natural resources in their environment. The oft-talked about Chipko Andolan (Hugging the Trees Movement) started in the seventies of the last Century by the women of Garhwal and later appreciated all over the world is the stark example of women being environment –conscious. Mountain women are extremely critical of the new commodity-led development activities that ignore catastrophic effects on the environment, jeopardise their natural resources and hit the roots of sustainability.

The current wave of agricultural transformation is all set to put the traditional knowledge, skills, technologies, strategies, beliefs, rituals, and other life values into extinction channel. The externally driven transformation is to affect the life of women the most and the women-driven CPR-based livelihoods in mountain areas. Women's perception of the formal-led intensively undergoing transformation in land-related systems and values in mountain areas is worth taking serious consideration. This not only helps us further develop an understanding of the unique traits of community-based holistic traditional agricultural systems but also acquaints us of the ills associated with the market-governed transformation processes.

- The new agriculture focuses on only single or a few commodities badly required by city dwellers in the plains of the country and abroad. Apples, for example, are cultivated mainly for plain people and soybean for feeding soya cake to animals in European countries. Flowers are being grown for Five Star Hotels in big metros. This all is taking place at the irreparable cost of myriad of crop varieties that thrive in mountains' diverse ecological niches and at the expense of total farm production so critical for local people. This transformation is leading to continual shrinkage in agrobiodiversity in mountain ecosystems and it ought to create an explosive situation of ecological vulnerability associated with extremely high degree of risks to marginal mountain farmers. And this would further aggravate plight of women in the area.
- Neglect of common property resources (CPRs) together with destruction of common forests, extension of tourist activities and transport into virgin natural areas in the mountains is delinking farming from uncultivated areas that are vital sources of useful biomass – fuelwood, fodder, timber, medicinal herbs, variety of foods, raw material for small-scale industries – and supportive of food security. Under the umbrella of liberalisation, privatisation and globalisation (LPG), the virgin pristine areas would be increasingly privatised in the years to

come and rendered inaccessible to women. The LPG-oriented transformation would annihilate the community-based agricultural system to the worse of the sensitive communities inhabiting high undulated ecosystems.

- With focus on isolated farm activities with the on-going negligence of forests, distance between forests and farmlands would increase and this would significantly increase women's workloads. Women will be left with no option but to detain their daughters from attending schools to assist them in their difficult chores.
- Introduction of dwarf crop varieties and emphasis on the crops that yield no fodder has already increased pressure on women. They now have to cover long distances in search of fodder for their livestock. The cash crop-based agricultural transformation is isolating cropping from animal husbandry and is all set to devastate the age-old practices of animal husbandry in mountain areas. This state would bring lot many miseries to women and their children.
- As the transformation processes generated in male mind intensify, women feel more and more alienated from the new agro-technologies and activities in their environment. When their male counterparts assume the centrestage of transformation processes, women's traditional knowledge and skills relating to resource conservation, environment management and biodiversity management are devalued. In the new male-dominated food production system women are a marginalised lot, losing their social status and values. They cease to be natural resource managers and custodians of seeds and biodiversity.
- Agricultural transformation has robbed the soils of their natural fertility. Export of nutrients leaves the soil infertile. The fertility is 'restored' by purchased chemical fertilizers. Excessive use of these fertilizers together with deadly pesticides – that is a pressing demand of transformed system – is deteriorating soil ecosystem, spoiling water sources and causing atmospheric pollution and inviting numerous risks to human health. The immediate victim of the pollutants is a woman who is always working on farms intoxicated with chemicals.
- Quest for cash in the transformed system is infinite. Food crops are replaced with commercial crops. Women's first role is to nourish their children with nutrients produced on their lands. The new system exports those nutrients to market system in exchange of cash. This cash cannot feed farm families directly. This also cannot buy the same high quality of foods that grew on local farms. The result is malnutrition and improper development of women's children. Moreover, commercial crops cultivated with much extra time and labour of women do not necessarily bring them fair share in the profits. Male members of family often use the cash to buy liquor. Consumption of alcohol by males has been increasing along with transformation of agriculture. The cash-spinning transformation thus has brought numerous miseries to women and their children.

5

Woman Power in Mountain Agriculture

I will lift up mine eyes unto the hills
From whence cometh my help
My help cometh even from the Lord
Who has made heaven and earth

– *Psalm 121*

Thousands of tired, nerve shaken, over civilised people are beginning to find that going to the mountains is going home; that wilderness is a necessity; and that mountain parks and reservations are useful not only as fountains of timber and irrigating rivers, but as fountains of life.

– *John Muir (1898)*

Here the hills are earth's bones,
Jutting up out of her,
Here she died long since
Here fell to decay,
Demolished by storm and rain,
Her skeleton hardened to stones
That grow not the flesh again.

– *Dorothy Wellesley from "Asian Desert"*

A mountain becomes great as a human personality does, by extending its influence over the thoughts, words and actions of mankind.

– *R.L.G. Irving (1940)*

Oh, what a beautiful world it is, that blossoms in diversity.

– *Henryk Skolimowski (2001)*

Most of the rural population in the Himalayan mountains is engaged in naturally sustainable but marginal agriculture. Women have primary roles in building up agriculture-based livelihood systems, providing much of the labour required for agricultural activities. A high degree of sexual division of labour is visible in Central Himalayas as also virtually in all the countries of the Hindu Kush-Himalayan region.

No Alternative to Animate Energy

Mountain agriculture cannot afford to use mechanical energy for agricultural operations. Animate energy is the only feasible source with no viable alternative. Bullocks and humans are the exclusive source of animate energy to carry out all agricultural operations. Among the humans; women are the major source of power to keep the agriculture going. In other words, cattle bullocks and women are the two main sources of motive power for mountain agriculture.

Experiences show that there is a direct relation between the level of energy use, either human, animal or fossil (mechanical), and the level of production per unit of land. In fossil energy-driven systems, the relatively high energy use explains the relatively high productivity in the transformed Green Revolution areas. However, there are organic, integrated systems in which virtually no fossil energy is used, which, in terms of overall production, are at least as productive as modern systems, but have less negative impact on the environment and may be socially more acceptable (Durno *et al.* 1992). That the source of energy is not important for the level of production is also demonstrated by comparative research in the Philippines (Kuether and Duff 1981), where it was found that the same yield of rice could be obtained in mechanical, transitional and traditional farms. Basing policies on comparing energy balances only, therefore, can lead to wrong decisions if these data are not combined with information on, e.g., production, availability, cost, impact on environment, gender and the community as a whole (Reijntjes 1992).

Agricultural transformation and mechanization often go hand in hand. But, in this respect too, mountains are the exception. Almost complete transformation in some favourable pockets of the mountains, it has been experienced, has not invited mechanization of any degree. In transitional areas, e.g., the Shivalik and Foot-hill range where handful farmers occasionally use hired tractor for land preparation, a very limited use of fossil fuel energy is visible, and it is because of the availability of even land which is easily accessible and well-linked to the plains (Singh 1998a).

Energy systems used for agricultural work in the mountains exist as an integrated system. Farmer-manual tools system can exist independently; and, to a great extent, so can the farmer-machine system. But the farmer-animal power system can never exist independently. When, through the use of an implement, an agricultural operation absorbs some amount of animal energy, it would simultaneously absorb some amount of human energy. So both systems (animal power being dominant) are inseparably integrated. Use of a mix of energy technologies in crop production is referred to as integrated energy system. We can call this energy system for agricultural work as 'animate energy system' since the energy is produced by the living system.

The fossil-fuel energy, on the contrary, may be referred to as inanimate energy. The former is renewable, the latter non-renewable. In this text, unless specified, the word 'energy' has been referred to the form of energy which is used for agricultural work, e.g. tillage, weeding, puddling, threshing etc.

Animate energy based system is obviously the most suited to mountain agriculture. Why does animal power seem to be the best source for developing sustainable agriculture in the mountains and why is it superior to fossil fuel powered machines? A number of sound reasons can be given for this. Arguments in favour of the draught animals have been derived from earlier studies (Gill 1981, Bhalla and Chadha 1982, Nair 1982, Ramaswamy 1983, Bodet 1987, Singh and Naik 1987a and Reijntjes 1992) and have been looked at from the mountain perspective. The following points have been derived after Singh (1998a):

- The sources of energy already exist in the region. Animate energy does not have to be manufactured or bought at a high cost.
- The use of animate energy considerably increases a farmer's work force. It enables the farmer to diversify the crop planted, to increase the cultivated area of the farm, to carry out agricultural work in time.
- Machine-based energy system causes the production activity to concentrate on a limited number of crops, thus reducing the diversity of the production system. The animate energy system does the other way round what is preferred in mountain agro-ecosystems.
- Animal-drawn plough and other implements are cheaper and more affordable than a large tractor-drawn plough/ power tiller. Animal-drawn implements can be made in the village itself and are more suitable for the small, often fragmented and scattered, farms found in the mountains.
- Use of bullocks does not entail any investment in expensive and non-renewable fuel. Another enormous advantage of the ruminants used as draught animals is that they can be fed residues and by-products available on farm, producing in return not only energy but food (milk from the female cattle), methane (biogas) for lighting and cooking, manure to fertilize the fields, and many other products obtainable after their death without competing with people for food.
- The use of bullocks enables the farmers to integrate livestock with crop production and permits the exploitation of the very large potential of cattle kept on settled, subsistence farms.
- Mechanization causes direct labour displacement in land preparation. If it does not also contribute directly to increasing cropping intensities and yields, or a switch to more labour-intensive crops, there will be a net loss of employment opportunity in areas, e.g., the mountains, where alternative sources of income are extremely meagre.
- Fossil energy to be used in the machines is a finite resource and its use has a considerable negative impact on the environment and most farmers in the mountains cannot afford fossil energy-based technology.
- Where animals are used as draught power, it is possible for farmers to cultivate more land or they make time free for other activities.

The above-listed arguments clearly reveal that animate energy system excels the mechanical energy. In the mountain areas, owing to specific resource base characteristics altogether different from those of the plains, improvement in bullock power system efficiency and its sustainable use is an imperative to improve the lot of women folk.

Woman Work Hours

Use of human energy is inevitably linked with all agricultural operations carried out by draught animals, i.e., ploughing, levelling, puddling, weeding and threshing. Other operations – hand-weeding, irrigation, manure transport and application, breaking of clods, sowing and transplantation, fertilizer and pesticide application, harvesting and hand-threshing – use only human energy. Many of these operations use only women power. Here bullocks means a pair of bullocks while man and woman denote only single individual performing work together with a pair of bullocks or alone.

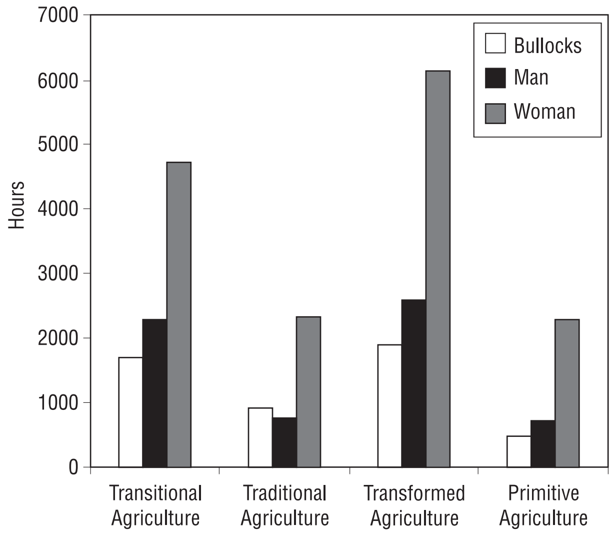
Among the four areas studied, the transformed middle mountain villages require maximum bullock and human hours followed by the Shivalik villages. Total bullock hours requirement by traditional Middle Himalayan villages is nearly twice of the Greater Himalayan villages (Table 5.1).

Woman work hours devoted to all agricultural operations per hectare of cropland over a period of one year have been compared with those of man and bullock hours. The information is based on the investigation of 12 villages situated in four different agro-ecological zones, three villages in each zone. There are four peculiar agro-ecological zones prevailing in the region, namely, the Shivalik hills, middle mountains under traditional agriculture, middle mountains under transformed agriculture, and Greater Himalayas. These four types of agro-ecological zones are distinguishable from each other, geo-physically, ecologically, and socio-economically.

From Table 5.1 (all values expressed in terms of one ha cropland over a period of one year), it is clear that a woman devotes far much more time to agricultural activities than bullocks and a man. A woman in the Shivalik hills spends 757 more hours than a pair of bullock and a man together do. In the middle mountains under traditional agriculture, a woman spends 645 more hours than a pair of bullocks and a man together do. In middle mountains under transformed agriculture two bullocks and a man devote 1671 less hours than a woman. In the Greater Himalayas, agriculture uses 890 more hours of work by a woman than by two bullocks and a man (Fig 5.1).

In Shivalik agriculture, a woman devotes 2.79 times more hours of work than a pair of bullocks and 2.08 times more than a man. In traditional middle mountain agriculture, a woman spends 2.5 times more hours of work than a pair of bullocks and 3.04 times more than a man. Transformed middle mountain agriculture consumes as much as 3.25 times greater woman work hours than a pair of bullocks and 2.38 times more work hours than a man. The Greater Himalayan agriculture consumes 4.41 times more hours of a woman's work in comparison to a pair of bullocks and 2.91 times more than a man for all the operations required for the cultivation of single ha of land over a period of one year.

Fig 5.1. Time Consumed in Agricultural Operations per ha per Year in Different Types of Agriculture in Mountain Areas



On the basis of perday work load on a woman farmer, it may be observed that she devotes as many as 17 hours exclusively to agriculture-related work in the villages under transformed agriculture. In transitional hill agriculture (the Shivalik Hills), she works for as many as 13 hours a day. Traditional middle mountain agriculture requires a woman to devote only little over six hours a day, while in primitive-type Greater Himalayan agriculture she does agriculture-related work at the rate of less than six hours a day.

We thus can infer that it is the transformed agriculture that imposes the most burden of work on women folk. The transitional agriculture is at number two in this regards. Traditional agriculture puts comparatively less burden on women farmers. The Greater Himalayan agriculture requires minimum work input by a woman farmer.

Table 5.1: Working Hours of a Woman Devoted to Various Operations for Crop Cultivation per Hectare of Cropland in Different Agroecological Zones of Central Himalayas in a Year

Agricultural Operation	Source of Animate Energy	Shivalik Hills	Middle Mountains: Traditional	Middle Mountains: Transformed	Greater Himalayas
Ploughing	Bullocks	1000	486	1296	351
	Man	1000	486	1485	378
	Woman	00	00	00	00
Levelling	Bullocks	225	18	95	45
	Man	225	18	95	81
	Woman	00	00	00	00
Puddling	Bullocks	60	30	63	00
	Man	90	15	63	00
	Woman	90	15	126	00
Weeding	Bullocks	80	108	81	00
	Man	80	108	81	00
	Woman	496	192	1262	200
Irrigation	Bullocks	00	00	00	00
	Man	100	50	100	00
	Woman	32	16	50	00
Manure Transport & Application	Bullocks	00	00	00	00
	Man	00	00	00	00
	Woman	1000	475	1175	400
Clod Breaking	Bullocks	00	00	00	00
	Man	00	00	00	00
	Woman	180	100	278	100
Sowing/ Transplantation	Bullocks	00	00	00	00
	Man	100	19	106	80
	Woman	644	70	700	100
Fertilizer & Pesticide Application	Bullocks	00	00	00	00
	Man	300	00	300	00
	Woman	25	00	50	00
Harvesting	Bullocks	00	00	00	00
	Man	80	00	280	100
	Woman	1600	960	1700	800
Threshing	Bullocks	330	275	355	75
	Man	300	70	70	75
	Woman	660	500	800	475
Total	Bullocks	1695	917	1890	471
	Man	2275	766	2580	714
	Woman	4727	2328	6141	2075

Power Output during Different Agricultural Operations

Work done for certain length of time by different sources of power for agriculture can be converted into actual power invested in mountain agriculture. Experiments on draught animal power (DAP) output during ploughing, levelling, weeding, and threshing operations have been conducted at different sites in 12 villages under all agro-ecological conditions by Singh (1998a). Data for various operations has been derived from these experiments (Table 5.2). For threshing operation, energy estimate of 0.25 kW (Singh and Naik 1987a) was used.

Measuring the energy content of human labour which is one of the major sources of motive power in rural energy systems, is infinitely more complex, both conceptually and empirically. In particular, relation to human labour complexities arise because of varying views as to whether human labour is a factor of production that is substitutable by energy, or a form of energy that is substitutable by other forms of energy (Ramani *et al.* 1995).

However, for the ease of analysis of a production system and/ or ecosystem functioning inevitably depicting energy flow pattern, considering human labour in terms of energy, becomes urgent particularly when a concrete strategy is to be evolved. Considerable variation in the criteria of converting human labour into energy content exists in the past studies. Energy figures used by Revelle (1976), Gopalan *et al.* (1979) and Bhatia and Sharma (1990) appear to be towards higher side. In our analysis we have used human energy input value sponsored by ICAR (1978), i.e. 0.1 hp or 0.075 kW per adult per hour, for it appears appropriate when we compare human weight with that of a local bullock. Singh (1998a) has also used the same criterion.

Energy Contribution to Crop Cultivation

Table 5.3 presents data on the magnitude of power that actually invests into the cultivation of all crops through various operations. All figures are based on per ha of cropland per year. In order to generate data on actual DAP contribution to the cultivation of individual crops per ha per year, the total hours devoted to an operation for the cultivation of a crop were multiplied by the DAP output (kW) for respective operations shown in Table 5.2. For threshing operation, energy estimate of 0.25 kW (Singh and Naik 1987a) was used. One man-hour has been considered equal to 0.075 kWh (Ram 1982; Singh and Naik 1987a).

The total DAP for raising all major crops is the lowest (217 kWh) for the Greater Himalayas and the highest (851 kWh) for the transformed middle mountains. Most of the DAP is expended through ploughing operation in all the agro-ecological zones of the Himalayas. Overall amount of power input in agriculture by a woman is lower than by a pair of bullocks. However, if power of only one bullock is considered, power input figures of a woman and that of a bullock are quite close in the Shivalik and traditional middle mountain zones. But, in the transformed middle mountains and the Greater

Table 5.2: Bullock Draught Power Output During Different Agricultural Operations

Operations	Average Speed (km/h)	Tractive Effort (kgf)[1]	Power (kW)[2]
Ploughing	2.4	78	0.52
Levelling	2.7	48	0.36
Puddling*	1.6	95	0.42
Weeding & Earthing up*	2.6	47	0.34

Source: Singh (1998a)

Figures are based on eight hours' operation (seven hours' ploughing and one hour's levelling) by a pair of bullocks. Each bullock weighed 250 kg.

[1] 1 kgf = 9.806 Newton

[2] 1 kW = 1.34 hp

** Estimates based on Singh and Naik (1987a)*

Fig 5.2: Animate Energy Contribution to Mountain Agriculture

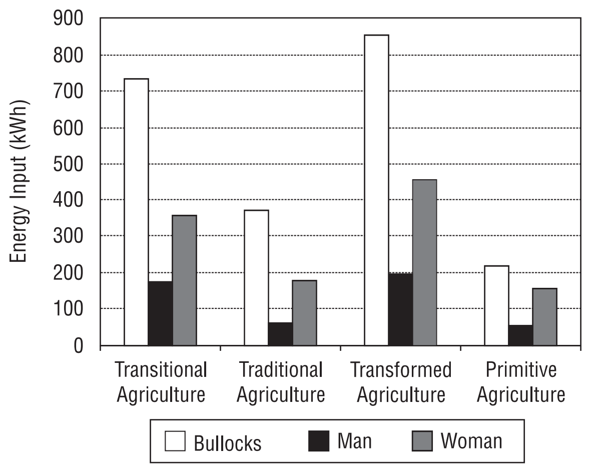


Table 5.3: Power Contribution to Agriculture (per ha per year)

Agricultural Operation	Source of Animate Energy	Shivalik Hills	Middle Mountains: Traditional	Middle Mountains: Transformed	Greater Himalayas
Ploughing	Bullocks	520.00	252.72	673.92	182.52
	Man	75.00	36.45	111.38	28.35
	Woman	00	00	00	00
Levelling	Bullocks	81.00	6.48	34.20	16.20
	Man	16.88	1.35	7.13	6.08
	Woman	00	00	00	00
Puddling	Bullocks	25.20	12.60	26.46	00
	Man	6.75	1.13	4.73	00
	Woman	6.75	1.13	9.45	00
Weeding	Bullocks	27.20	43.52	27.54	00
	Man	6.00	8.10	6.08	00
	Woman	37.20	14.40	94.65	15.00
Irrigation	Bullocks	00	00	00	00
	Man	7.50	3.75	7.50	00
	Woman	2.40	1.20	3.75	00
Manure Transport & Application	Bullocks	00	00	00	00
	Man	00	00	00	00
	Woman	75.00	35.63	88.13	30.00
Clod Breaking	Bullocks	00	00	00	00
	Man	00	00	00	00
	Woman	13.50	7.50	16.35	7.50
Sowing/ Transplantation	Bullocks	00	00	00	00
	Man	7.50	1.43	7.95	6.00
	Woman	48.30	5.25	52.50	7.50
Fertilizer & Pesticide Application	Bullocks	00	00	00	00
	Man	22.50	00	22.50	00
	Woman	1.88	00	3.75	00
Harvesting	Bullocks	00	00	00	
	Man	6.00	00	21.00	7.50
	Woman	120.00	72.00	127.50	60.00
Threshing	Bullocks	82.50	56.75	88.75	18.75
	Man	22.50	5.25	5.25	5.63
	Woman	49.50	37.50	60.00	35.63
Total	Bullocks	735.90	372.07	850.87	217.47
	Man	170.63	57.46	193.52	53.56
	Woman	354.53	174.61	456.08	155.63

Himalayan zone, power input by a woman is more than by a bullock (Fig 5.2).

The amount of human energy expended in mountain agriculture varies in the same fashion, being minimum in the Greater Himalayas and highest in the transformed areas of the middle Himalayas. Energy invested by a woman is two to three times more than by a man per ha per annum. Weeding, manure transport and application, sowing and transplantation, harvesting, and threshing operations consume much of woman energy.

This analysis presents only the crop production related activities a woman is devoted to. A woman also does most of the animal husbandry related activities. All other household chores are also to be accomplished by her. If she is supposed to devote only an hour per day, or 365 hours per annum, to non-cropping activities, she would be putting 27.37 kWh additional energy to get these tasks accomplished. Though this figure is towards lower side, but if added to her total energy output figures, one would certainly be led to appreciate that a woman, on the whole, surpasses the other two other animate sources of energy. This energy of a woman is so precious and critical for the land-related economy of mountain areas.

It is clearly revealed that the transformed agriculture – where a woman devotes more time and expends more energy – aggravates drudgery on woman. Green revolution-type transformation not only invites ecological, environmental, and socio-cultural crises, but also renders the production system unsustainable. An augmentation of draught animal power system would help mitigate woman's problems. For instance, improved animal harness, efficient implements and tools, increasing DAP supplies through more use of animals, and the likes would reduce work burden on a woman significantly. However, our conventional animal husbandry policy calls for large-scale crossbreeding of cattle. Crossbred bullocks have proved less efficient for ploughing and other agricultural operations. If the crossbreeding programme assumes success to a significant level, drudgery of women would further aggravate.

6

Case Studies: Traditional Agro-ecosystems

The (hill) people were well off and they used to export wheat, rice, coarse grains, oil seeds, ginger, saffron, herbs, walnuts, handmade paper, copper rods, musk, honey, ghee, woolen clothes, cows, bulls, ponies, etc., in the markets of the foothills and imported only gur (molasses), and cotton cloth.

– Trail, 1825

The people perish. They are accustomed to the process of perishing, customs and attitudes to life have appeared which accord with the process – the way children allowed to die and women made to overwork, and the widespread under-nourishment, especially of the aged. And this state of affairs has come about so gradually that the peasants themselves do not see the full horror of it, and do not raise their voices in complaint. For this reason we, too, regard the situation as natural and proper.

– Leo Tolstoy, 1899, Resurrection.

The hill man is indeed specially blessed by the presence in almost every jungle of fruits, vegetables and roots to help him over a period of moderate scarcity.

– Walton (cited by Bahuguna , 1989)

What a sad joke that a man from an industrialized agriculture region goes to an underdeveloped country to advise on improving agriculture! The only possible advice he is capable of giving from his experience is to tell the underdeveloped country to tap the nearest industrialized culture and set up another zone of fossil-fuel agriculture. As long as that country does not have the industrial fuel input the advice should come the other way. The citizen of the industrialized country thinks he can look down upon the system of man, animals and subsistence agriculture that provides life from an acre or two in India when the monsoon rains are favourable. Yet if fossil and nuclear fuels were cut off, we would have to recruit farmers from India and other underdeveloped countries to show the now affluent citizens how to survive on the land while the population was being reduced to a hundredfold to make it possible.

– Howard T. Odum, 1971

The varieties produced by the Green Revolution did not produce as well as old known races; in many situations, because the seed supplies had been used for food, the people could not go back to their original strains. The fact resulted in food shortages in many areas.

– Norman Baas, 1978

As the alcohol is to human beings, so are chemical fertilizers to soil.

– Bakhtawar Singh, a farmer in Bangali village in Garhwal

This variety of rice (Khera) is important from a religious point of view. In the worship of our family God, Gobin Maharaj, this variety of rice is absolutely needed and no other variety will do. The cooked rice from this species is equally delicious. From the rice straws, the floor mats are made and even the cattle have a special preference for this type of rice straw. This variety needs less fertiliser.

– Ram Ashraya Saha Kalewar, a Nepali farmer (2001)

Locally developed varieties can be superior to the commercially released high-yielding varieties.

– Sundaram Verma, an innovative farmer from Rajasthan, India (2001)

While speaking of subsistence farmers and biodiversity relationships, these custodians of genetic diversity are still maintaining crop diversity and varietal diversity within species, in spite of the threats of erosion. This has been possible because of the result of cultural practices and local knowledge systems built through the input of millions of unknown and invisible farmers.

– Dhruva Joshy (2000)

> The history of humankind has shown that all processes of harmonious social co-existence are built upon the notion of reciprocity; upon collective rights and norms that do not constitute property rights.
>
> – *Camila Montecinos (2002)*

> They say that we do not know anything
> That we are backwardness
> That our head needs changing
> For a better one.
> They say that some learned men are saying this about us
> These academics who reproduce themselves
> In our own lives.
> What is there on the banks of these rivers,
> Doctor?
> Take out your binoculars
> And your spectacles
> Look if you can.
> Five hundred flowers
> From five hundred different types of potato
> Grow on the terraces
> Above abysses
> That your eyes don't reach
> Those five hundred flowers
> Are my brain
> My flesh.
>
> – *Jose Maria Argguedas, A call to certain academics. Translated from the Quechua by William Rowe. Cited in Vandana Shiva's* The Violence of the Green Revolution

I. A Village in Rath

Village Bangali nestles, almost precariously, in Pauri district, at an altitude of about 1800 m from mean sea level. Chiefly dependent on agriculture like other mountain villages, this village lies in an area which is popularly known as Rath. The people who inhabit the Rath region are graziers-farmers who practice transhumance without nomadism, i.e., they take their animals to different areas in different seasons, but they do not vacate their homes and do not take their families and belongings with them.

The general landscape is treeless land; vast areas of mountains are bald. Despite this common malady of the region, the cultivated land is preserving a great variety of crops and their several varieties. Lush green forests can also be seen in the reserve areas, but they are poorly maintained. Village Bangali we chose for our study was better off compared to other villages adjacent to it. There are still relatively closed cycles of biomass flows from one sector of the system to the other (forests-animals-crops).

Bangali village is of moderate size with just 45 families. There are six persons per family on an average. On the basis of representative families, the total population of the village is 258. This comprises 51 adult males, 81 adult females, 81 male children and 45 female children. Some 24 persons of the total village population work outside the village, mainly in the plains. Out of those who have migrated, 43 percent are of potential working age (18-60 years). Forty-eight percent of the village resident population is below the age of 18.

Common Property Resources

There are two classes of community land – Panchayat and Civil-Soyam – managed by the people themselves. Reserve forests are under the control of the Forest Department. People have right to extract fodder and firewood from the reserve forest area. In summer season, villagers are given right to establish cattle stations, locally known as 'kharak', in the reserve forest area. This area is, thus, also used as a CPR.

The area under CPRs is much larger – about five times more – than the cultivated land area. Three villages of the Gramsabha, including the one selected purposely for the study, share biomass produced on the CPR areas. Carrying capacity of the CPRs is apparently high to take care of the livestock population in the three villages of the Gramsabha.

The forest cover on the Panchayat land consists of thin stands of trees. The forest type is the banj oak (*Quercus leucotrichophora*). This forest type is very dominant. The land is rocky and slopes steep. The almost pure forest is open, with an estimated canopy cover of 20-35 percent. Ground vegetation in the forest is almost absent. Rudimentary oak trees in the forest are indicative of their severe lopping for fodder and considerably high degree of pruning for firewood.

The forest cover on Civil-Soyam land is of better quality than on the Panchayat land. *Quercus leucotrichophora* is the dominant species. Chief associated species of this tree in the forest are burans (*Rhododendron arboreum*), ayar (*Lyonia ovalifolia*), and kafal (*Myrica esculenta*). A few plants of utis (*Alnus nepalensis*), not grown into trees, as well as some of mehal (*Pyrus pashia*) are also found. Shrubby species, like kingor (*Berberis asiatica*) and hinsalu (raspberry) are also present. This is by and large an open forest with a canopy cover of about 40 percent. Wild fruits, firewood, and fodder are collected from this forest. Minor timber, especially of oak, is also extracted from the forest. The forest floor is extensively used for grazing. Cattle and goats are the two species of livestock that subsist on grazing in the forest, though grass cover is sparse. The oak species is lopped so severely that a large number of trees are reduced to bushes.

The condition of the reserve forest is rather good. It is a mixed natural forest, and banj oak (*Quercus leucotrichophora*) is the dominant vegetation. The chief associates of the banj oak in this forest are burans (*Rhododendron arboreum*), ayar (*Lyonia ovalifolia*), and kafal (*Myrica esculenta*). Since the forest is situated at a high altitude of about 2200 m from mean sea level on the North-oriented slope, tilonj oak (*Quercus floribunda*) also shows frequent presence along with the banj oak. A more thermo phobic species compared to the banj oak, tilonj oak forms a transitional zone between banj oak at mid-altitudes and kharsu oak (*Quercus semecarpifolia*) at higher altitudes of the Himalayan mountains.

The reserve forest has a canopy cover of about 60 percent. Since *kharaks* (summer cattle stations) are there amidst the forest, it is obvious that it too does not abstain from biotic pressure. During summer and rainy months, a large number of cattle, buffaloes, and goats are kept in the forest; banj oak and tilonj oak leaves are heavily lopped and firewood is also extracted. Nevertheless, the reserve forest can be referred to as an 'ideal' forest, which is also obvious from its role in the maintenance of hydrological cycle.

The forest area provides the origin for a local *gad* (a small rivulet) that irrigates a part of cultivated land and provides drinking water to people. This *gad* is a tributary of Western Nayar, the river flowing northeast of the village Bangali. This rain-fed river has its origin in the Dudhatoli forest area.

The summer camps, or kharaks, have their own agricultural and life cycles. The families stay here almost the whole year, but others go to bring their cattle there during the summer period. Crops like potato, amaranth, and kidney bean are cultivated around the camps. In contrast to the situation in the village itself, the cattle are kept on free grazing here. Generally one crop is taken throughout the year.

Cropland

Cropland is the private property resource (PPR) on which food grains, dry fodder (in the form of crop residues) and, to a lesser extent, vegetables are raised. Green grass is also raised on the bunds of the terraced fields. Most of the vegetables are cultivated in the kitchen garden, which is essentially the homestead-based cropping system in the rural mountains. The village, on the whole, has 55.35 ha of cropland. Of it, about 85 percent is unirrigated, only about 15 percent cropland is irrigated. Each family, on an average, owns 1.23 ha (61.5 nalis) cropland (Table 6.1).

Table 6.1: Classification of Cropland, ha

Cropland	Per family	Village
Unirrigated/ rain-fed	1.04	46.80
Irrigated	0.19	8.55
Total	1.23	55.35

The general scenario of the private land, especially of the cropland, is of sparse trees and other woody perennials. The irrigated land is almost completely devoid of trees. The Southeast slope is largely rocky and steep. Terraces on the Northwest aspect are comparatively in good condition. The soils are largely gravely and their depth is shallow.

Livestock

Cattle and buffaloes are the main livestock in the village, as also in the area. Only two families, in addition, have a total of 150 goats. There were no sheep in the village. Poultry were also absent.

There were 365 domestic animals in the village, of which 44 percent were cattle. The percentage of buffaloes and goats was 15 and 41, respectively. Bullocks were the main motive force for agriculture. Cattle are the dual purpose species. They produce draught power and manure for agriculture and milk for family food supplies. Buffaloes are kept only for milk production. Since this species has no other role in the farming system, male buffalo calves are not necessitated. They are deprived of milk few days after birth and thus are starved to death. Only female buffalo calves are kept for rearing. The goat is a meat animal. It is kept exclusively on grazing, not fed at stall. Cattle are also grazed during day time, especially in summer and rainy season, but are also fed at stall at night. Buffaloes are almost completely stalled.

Table 6.2: Number of Different Livestock Species

Cattle	
Adult male	72
Adult female	36
Male calves	27
Female calves	27
Buffaloes	
Adult males	-
Adult females	45
Male calves	-
Female calves	9
Goats	149
Total	365

The term 'adult' means an animal that has calved or has begun to work, irrespective of its age.

Production

According to rough estimates, per capita production of main food crops – i.e., wheat, barley, rice, finger millet, and barnyard millet – per year in the village is nearly equal to 5.0 q. Almost all families have to supplement home production of main food grains with purchases. Each family, on an average, purchases half to one quintal each of wheat and rice per annum.

The general health of livestock seems to be much better in comparison to other areas of Garhwal. Their productivity is also comparatively higher. The average milk production per cow per day was 2.0 kg and that of a buffalo 5.0 kg per day. This milk also adds to the family food supplies. Twenty percent of the families in the village sell half of the milk produced, in the Chaura market, about 10 km down to the village.

It was also estimated that the animal power available in the village is well in accordance with the requirement.

Biodiversity

Plants and Crop Cultivars

One of the unique features of the farming system of village Bangali is that it is still conserving an enormous diversity of useful plants. People in the village relish on a number of food items, some of forest origin and others cultivated. Total number of plants providing different kinds of food items is 73. These include seven wild fruits which are obtainable from the forest area. There are 12 species of the other fruit plants which are cultivated by the farmers on the cultivated land and/ or on homesteads (kitchen garden). There are three types of vegetables that grow wild and are consumed by the villagers. Numbers of different types of vegetables people cultivate, mostly on homesteads, go as high as 22. Six types of condiments are cultivated or grown wild in the region. Number of cereals being grown by the farmers is nine, of pulses nine, and of oilseeds five.

Apart from these, 11 species of trees and bushes are fed to the animals that also become part of human diet after being converted into milk.

Bhang (*Cannabis sativa*) is grown not only for a condiment prepared from its seeds, but also for fibre. Ringal, a bamboo species, is grown for basket making. *Cannabis sativa* is raised in the terraces near homesteads at a small scale, while ringal is grown only by few farmers.

Intraspecies diversity too is remarkable. There are three landraces of wheat with different shapes and sizes of ears, length of plants, taste, and fodder value. *Mundariya* landrace is preferred for making chapattis because of its preferable colour and extraordinary taste. Kisao wheat's ears are similar to that of introduced varieties (HYVs), but it is long-stalked, though not as tasty as the former variety. Lalmishri landrace is sown on higher altitudes where snow falls during winter. Its grains are tasty. It is especially liked for its high fodder value.

There are as many as nine landraces of rice being cultivated by farmers on large scale. There might be numerous other varieties in the region, but these nine are on farmers' tips. These have different sizes of grains, colours, tastes, aroma, and so also do have different properties. Klaun rice is especially rich in aroma and has medicinal value as well. This is provided to those who fall ill. All the rice landraces are long-stalked. Farmers did not allow any dwarf / modern variety to enter their crop fields so far. The Himalayan region has been a rich repository of rice landraces since centuries. Farmers demonstrate special interest in the discussion of their rice landraces.

There are three prominent landraces of mandua, the fingermillet, extensively cultivated by farmers. Two landraces of jhangora, the barnyard millet, are given place in the cropland. There is no considerable difference in the taste of the varieties of these two species. These millets form the popular staple food for the farm families. The millets are never cultivated as pure crops. They are always intermixed with a variety of pulses, kidney beans, pseudo cereals, and *junala*, a sorghum species.

The landraces of amaranth number nine. The *kedarchua* or *kedari marsa* with rose-coloured ears hanging downwards is generally grown in the kitchen gardens and its leaves are used as vegetables. Other varieties cultivated with *mandua* or intermixed with kidney beans are to produce grains, but their leaves are occasionally used for making vegetables. Amaranth (grains) is sometimes used for consumption at home, but it is mostly bartered. One kg of amaranth fetches five kg salt, 125 g tea, half a kg sugar, half a kg wheat, and half a kg of rice.

Kauni or kangani (the foxtail millet) is cultivated on a very small scale; only few plants of it will be visible in the fields of *jhangora* or *mandua*. Farmers identify two landraces of *kauni*. There are no specific names of these.

Biodiversity in the pulses is also of high magnitude. There are dozens of varieties of seed *rajma* (frenchbeans). Four landraces of *bhat* are recognized by the farmers. There are many many varieties even of other pulses, but there are no specific names of these. Varieties of these pulses are specified by the farmers on the basis of the colours of their seeds (seed coats). *Bhat* (also known as black soybeans) is the

Table 6.3: Diversity of Plant Species Providing Food

Wild Fruits	Kafal, Bedu, Bhamora, Kingor, Hinsalu, Ghingharu, Melu
Cultivated Fruits	Orange, Galgal, Aru (Peach), Nashpati (Pear), Apple, Malta, Khubani (Apricot), Akhrot (Walnut), Pangar (Chestnut), Plum, Anar, Badam, Banana
Cultivated Vegetables	Potato, Kaddu, Loki, Karela, Brinjal, Frenchbean, Sem, Bhujela (Petha), Chichinda, Radish, Rye, Bhindi (Lady's finger), Methi, Palak, Oogal, Marsha (Amaranth), Genthi, Tedu, Mirch, Chillies, Carrot, Pea
Cultivated Condiments	Ginger, Turmeric, Coriandum, Bhangjir (grows wild), Bhang (*Cannabis sativa*), Mirch
Fodder Trees/ Shrubs	Banj, Tilonj, Kharsu, Kharik, Papri, Kirmoli, Bhimal, Bedu, Guriyal, Desmodium, Furpatta, Sakina, Kandali
Cereals	Wheat, Barley, Rice, Mandua (Finger millet), Jhangora (Barnyard millet), Kauni (Foxtail millet), Marsa (Amaranth), Oogal or Phapher (Buckwheat), Junala (*Shorghum* spp.)
Pulses	Bhat (Black soybeans), Urad (Black gram), Moong (Lentil), Riyans (Rice bean), Gahat (Horse gram), Soybeans, Tor (Pigeon pea), Pea, Soonth
Oil Seeds	Mungphali (ground nut), Til (Sesame), Toria (Rapeseed), Sarson (Mustard), Surajmukhi (Sun flower)
Fibre Crop	Bhang (*Cannabis sativa*)

Table 6.4: Number and Names of cultivars/ Landraces of Different Crops

Crop	Number of Cultivars/ Varieties/ Landraces	Local Names of the Cultivars/ Varieties/ Landraces
Cereals		
Wheat	3	Mundariya, Kissao, Lalmishri
Rice	9	Chauriya, Bunkua, Bankuli, Syalu, Jamola, Dudha, Banpashum, Klaun, Jolia
Mandua (Finger Millet)	3	Ghariya Kodon, Manen, Bali
Jhangora (Barnyard Millet)	2	Safed (white), Lal (red)
Amaranth	9	Kedarchua, others are named according to colours of the ears – red, black, white, yellow, grey, brown, green, slaty, etc.
Pulses		
Bhat (Black Soybeans)	4	Black, yellow, green, desi (almond colour)
Rajma (Seed French beans)	> 12	Red, thin, green, white, yellow, etc.
Soonth	2	Black, almond-coloured
Oilseeds		
Sarson (Mustard)	2	Yellow (Raru), black (Dain)
Sunflower	2	Bearing one flower, many flowers
Vegetables		
Potato	2	Gol (round), Pahari
Kaddu (Pumpkin)	2	Gol (Khirboj), Lamboo (Kakha Tumra)
Loki	2	Gochhal Tumdu, Lambi Garden (Long neck)
Brinjal	2	Gol (round), Lamba (long)
Karela	2	Kadua (bitter), Meetha (sweet)

Note: This is all on the basis of farmers' own perspective.

most popular pulse fondly eaten in the form of several recipes by local people. All the pulses are cultured with *mandua* (in case of frenchbean, amaranth) as the base crop. Pure culture of theirs is rare. If the land is highly degraded, then sometimes only pulses are grown on it.

Local vegetables also witness several varieties in each case. All vegetables, except potato, are raised in kitchen gardens as the main components of the homestead based cropping systems in the mountains. Farmers identify different varieties of vegetables on the basis of the size and shape (sometimes of colour) of their edible parts. Vegetables are consumed by the farm families and are not sold in the market.

Among the oilseed crops, mustard has two varieties as identified by the farmers and sunflower only one. The former is sown mixed with wheat while the latter is seen in fewer numbers of plants in the kitchen gardens.

Cultivars/ landraces mentioned above are those that are readily identified by farmers. However, there might be many more other landraces/ varieties that are still non-descript. Farmers do not have much concern with the outside world. They are content with their own landraces and the necessary knowledge and skills they have command upon and are rich source of.

Animal Breeds

Bullocks

Bullocks are mostly black, white, and red coloured. Farmers identify two breeds: *Ghariya Balad*, which is the non-descript Hill breed, and desi, which is the Terai breed, Pawar. We also found some crosses of Pawar and Hill and Haryana and Hill breeds. The non-descript Hill breeds are of light body weight and smaller size. White colour is highly preferred over red and black. The bullocks have straight legs with long hoofs. Their smaller size and light body weight are advantageous for hill farming systems. The long hoofs are helpful for walking and grazing on graveled and stony paths and acute slopes. The local hill breed is very hardy and very much liked by hill farmers.

The Pawar breed is imported from the Terai area of the Himalayas, mainly from Ramnagar in district Nainital. This breed is somewhat larger and heavier than the Hill breed. Pawar has a highly developed hump and is quite suitable for ploughing purposes. The Haryana x Hill crosses are still larger in size and heavier than Pawar x Hill crosses. These crosses are mostly imported from plain/ Terai areas as cows of the Terai/ plain areas are not available in the study area.

The breeds of the bullocks farmers maintain are suitable for all agricultural operations in the small terraced fields carved out on treacherous mountain slopes.

Cows

The cows in the study village are of smaller size, having light body weight and comparatively long hoofs. They are of non-descript type, which we call the Hill breed. Their height at withers reduces with increased altitude. They are mostly of white, red, and black colour, with bright eyes, small and active ears, and small, sharp horns facing forwards.

Cow breeds are quite hardy and adapted to the harsh conditions of the mountains. They can thrive well on poor vegetation. The udder and teats are less developed. The black coloured cows are called Guari. White colour is preferred over red and white. The hill cattle are quite resistant to flies' attacks and also to ticks and tick-borne diseases.

Buffaloes

Buffalo breeds found in the mountain, as also in the study village, are imported from the plains. Most of them have an admixture of Murrah, Nili Ravi, and Bhadawari breeds. There is, as such, no pure hill breed. The buffaloes are specialized milch breeds in the mountains. They are reared exclusively for milk production. In contrast to the cattle, which are multipurpose animals, buffaloes are the single purpose animals.

Farmers' Views on New Agro-technology

The wave of the modern agro-technology in mountain areas could not wean the farmers off this village away from their traditional farming. With experience from the irrigated valley areas in the mountains where the modern or the Green Revolution technology has captured its roots, farmers in this village did not even try new seeds of any crop.

Only one element of the new 'package' – chemical fertilizers – could somehow enter their farming system. There are only fewer than 10 percent farmers who would apply chemical fertilizer – mainly the di-ammonium phosphate (DAP) – and that too in very small amounts, much lower than the recommended doses in the soils in which wheat has to be sown. Only one or two farmers use urea for topdressing the wheat crop in irrigated terraces. Majority of the farmers abstain the application of chemical fertilizers. No farmer uses pesticide of any sort. All tools and implements of the farming are theirs own.

Among the fruit trees, *nashpati* and *melu* were introduced. All the traditional crops continue to be cultivated. The only crop that people have ceased to raise is *cheena* (proso millet) for about 20 years. Kauni (foxtail millet) that occupied much larger area in the previous years, nearly 20 years ago, is now given less importance.

Views all people expressed about the modern agro-technology are alike. The people not only understand the system they are part of deeply, but also project the strategies that could be most amicable for their environment and society. Some of the views expressed by the people are as follows.

- We do not follow to sow new seeds of crops as they demand application of chemical fertilizers and pesticides, which we cannot afford to purchase.
- The new varieties of crops are water guzzling and ours (traditional) are hardy, demand much less water or grow even without any irrigation, with the help of just rainwater.
- The dwarf crop varieties produce less fodder and so they are not supportive of our livestock.
- Chemical fertilizers degrade the soils. Their doses have to be increased year by year or the new crops would be destroyed.
- As the alcohol for human beings, so are chemical fertilizers for soil.
- Lot of difficulty is faced in the preparation of fields, mainly during tillage, in which chemical fertilizers were used in the previous crop.
- New seeds – the HYVs – are not as tasty as our traditional seeds.
- Adopting new varieties of seeds would mean dependence on others: the public sector, private companies, market, etc.
- It is also not easy to learn the cultivation techniques associated with new varieties. Their cultivation techniques would snatch away our own traditional knowledge and skills.
- Even if we are guaranteed that all necessary inputs of modern agriculture would be made available to us in time and even at subsidized rates, we are not going to lose our own germplasm, for without that we shall be completely dependent on the tools that are not ours own.
- Our own traditional crop varieties are extremely hardy. They do not invite any pests or diseases. The new varieties, however, are heavily damaged by pests and diseases and cannot be saved without the applications of pesticides.

Gender

Women and men share a lot of their tasks. The women are engaged in all household chores, water and fuel collection, land preparation, sowing, weeding, harvesting, post-harvest activities, and seed selection. All activities related to animal husbandry – like fodder collection, cleaning of the animal sheds, milking, and tending the animals. Men assist in transport and collection of fuel, fodder, and water, tending the animals, land preparation, and some post-harvest activities.

Amongst the children, it is mainly the girls who assist in all these activities. Both boys and girls attend the village school, though the number of girls going to school is less and their enrollment is finalized at an earlier age.

The girls in the village were formerly married to the boys outside the village at an age of about 12 to 13 years. At present, girls stay somewhat longer at their parents' house, to get married at an age of about 16 to 18 years. Instead of a small bride price, at the moment already dowries are being paid.

A woman gets up at about 5.00 a.m., starting the day with tending (open) fire and making *chai* (tea). Then she cleans the house, takes care of the children, cleans the animal shed, milks cow or buffalo, collects water, prepares breakfast, and starts her agricultural activities. Her working day, in which she has some short moments of rest, ends about 9.00 p.m.

Male member, often the male head of a family, takes all the decisions regarding expenditure, investment, sale or purchase of animals, and any thing where money is involved. Women are generally the passive workers always doing selflessly for the welfare of their families. A woman has her say in all the social and cultural activities where cash economy is not in question.

II. A Village in Henwal Valley

The Study Area

Henwal valley lies in the central part of the Tehri Garhwal district of the Central Himalayas. The valley stretches from the Surkanda range of mountains in the North to the Shivpuri in the East. Henwal River is the main rain-fed river in the valley that takes its origin in the dense natural forests of the Surkanda range and drains into the Ganga in Shivpuri, a few kilometers above Rishikesh. Shivpuri lies in the Pauri district of Garhwal. The altitude of the Henwal valley ranges from less than 800 to above 3000 msl.

The valley area comprises narrow belt of flatland or moderately undulated land along the Henwal River which is used for agricultural purposes. The upper areas are mostly covered with natural oak forests. Large parts of the natural forests have been transformed into apple orchards. The famous Chamba-Mussoorie Fruit Belt lies in the upper reaches of the Henwal valley.

Socio-economic Features

Jardhargaon, the village selected for the specific study, is one of the well-known villages of the Henwal valley. Located in the Bamund Patti of Chamba Block of Tehri district at an altitude of about 1500 msl, the village is like the other typical mountain villages. This village, however, has witnessed both traditional and modern stages of agriculture. But the village has now resumed the organic way of life and has taken to the path of sustainability interwoven around its natural resources, including biodiversity.

There were a total of 290 families in village Jardhargaon. Total population of the village was 1815, out of which 801 were males and 1014 females, with a sex ratio of 1266 females per 1000 males. Average family size was 6.26. This family size is moderate. The village is somewhat remotely situated between a flat valley on the banks of river Henwal down below and lush green oak forest above.

Land Use

The land is of three types: the private land, the community land, and the reserve forest land. Private land includes the cultivated land or cropland, private grasslands, and orchards. Few families also have some private land in the reserve forest area, in the vicinity of the summer camp on which they have legal rights. The land around summer camp (also known as *daanda*) has been included under cultivated land. Community or common land includes Civil-Soyam and Panchayat land. The district revenue department manages civil-Soyam almost exclusively for the benefits of the villagers. Panchayat land is owned and managed by the Panchayat body for villagers' use only. The reserve forest area belongs to the Government (Forest Department) but the people are provided limited rights of gathering firewood and fodder from this land.

Area under the community land is approximately 800 ha, i.e. about five times that of cultivated land area. This much common forest area is shared by four villages in the Jardhargaon Gramsabha. Area under the reserve forest is more than this and people of more than a dozen villages use the biomass (fodder and fuel wood and many edible products) from this forest ecosystem. This area also provides origin of some small water sources from which water is supplied virtually to all the villages inhabited below this area.

Table 6. 5: Land Use in Village Jardhargaon

Type of Land	Area (ha)
Uncultivated area	
Community Land	App. 800
Cultivated Land	
Irrigated	32
Unirrigated	200
Total Cultivated Land	232

Note: Community land is shared by the other villages of the Gramsabha of Jardhargaon

Total cultivated area in the village is 290 ha. About 16 percent of the total cultivated land in the village is under irrigation by Henwal River (Table 6.5). Landholding size is very small, about 0.8 ha. Almost all farmers are small holders. Again, there is very high degree of fragmentation and scattered ness of farmland that causes difficulties in its management. Overall picture would reveal that the degree of inequality in Jardhargaon, as also in other mountain villages, is not as high as in the plain villages. The holding size though is small, there is hardly any landless (or landlord) in mountain villages. Reduction in the size of landholding is a continuous phenomenon, resulting from the increase in the size of families and family fragmentation.

Mountain Crops

Compared to the so-called Green Revolution areas in the plains where a few cereal crops, pulses, and cash crops in the monocropping pattern is the dominant scenario of agriculture, mountains still give way to raise a pretty large number of crops. In some areas easily accessible to the conventional development activities, however, some crops have vanished and some are likely to vanish in the years to come. In the remote areas, on the other hand, almost all crops being grown since centuries still continue to flourish to date. Apart from the interspecies diversity, the intraspecies diversity in crops too is of appreciable measure.

In Jardhargaon, virtually all crops that occur at the mid-altitudes are being raised in the upland/ rain-fed areas. Very many varieties of each crop will also be found in the upland cropping system. Irrigated cropping system has crop rotation of just two cereal crops: rice and wheat. At one point of time, only some four HYVs of rice had replaced almost all the landraces. Now, however, most of the landraces have returned to the area thanks to the efforts of the village farmers.

The rain-fed cropland is agroforestry system with *Bhimal* (*Grewia optiva*), *Kharik* (*Celtis australis*), *Guriyal* (*Bauhinia* spp.), *Timla* (*Ficus* spp.), oak (*Quercus leucotrichophora*), etc. as the main woody perennials integrated with cereal crops. *Grewia optiva* at lower and mid-altitudes and *Quercus leucotrichophora* at some higher altitude are the most frequently occurring woody perennials managed with annual crops. The other tree species are less frequent. Virtually all the woody perennials in the agro-forestry system are of good fodder value.

Area under Different Crops

Among the Kharif (summer) crops, rice occupies 26 percent area. Coverage of the rice crop would depend mainly on the extent of irrigation facilities. In village Jardhargaon, 52 percent of the rice is concentrated in the irrigated land. The rest is sown in the uncultivated/ rainfed area. Rice is sown directly in the rainfed area. In irrigated land, however, almost entire area under rice is transplanted. Finger millet (mandua) occupies the largest area (35 percent) in Kharif season. This important millet crop covers only the rainfed area and is never cultivated as a pure crop. It is intercropped with amaranth, buckwheat, jakhia, and all pulses.

Table 6.6: Area (ha) under Different Crops in Jardhargaon

Crops	Area in ha (percent)
Kharif (Summer) Crops	
Rice	61.0 (26.0)
Finger Millet	80.0 (35.0)
Barnyard Millet	51.0 (22.0)
Amaranth	20.0 (9.0)
Pulses	10.0 (4.0)
Vegetables	7.0 (3.0)
Other Crops	3.0 (1.0)
Total Area Cultivated	232.0 (100.0)
Rabi (Winter Crops)	
Wheat	140.0 (60.0)
Barley	14.0 (6.0)
Lentil	14.0 (6.0)
Oilseeds	8.0 (4.0)
Vegetables	5.0 (2.0)
Total Area Cultivated	181.0 (78.0)
Area left Fallow	51 (22)
Total Cultivated Area in the Two Seasons	413.0
Total Area under Cultivation	232.0
Cropping Intensity (%)	178

Note: Figures in parentheses are percentage of the total area under cultivation.

Barnyard millet (jhangora) is provided about 22 percent area in the rainfed land.

Nine percent of the area in the upland area is devoted to amaranth, which is often intermixed with kidney beans. Some pulses, e.g., horse gram (gahat) and pigeon pea (tohar), are cultivated in pure form also on land not good for cereal crops. These pulses occupy about 10 percent of the upland cultivated area.

Vegetable farming is not intensive and market-linked. Some seven percent area, mostly around homesteads, except potato which is cultivated in the high areas of upland, is devoted to vegetables for consumption at home (Table 6.6). Some farmers occasionally sell vegetables, particularly potato, in the local market.

Entire area of cropland is cultivated in the summer season. During rainy season following just after the sowing of seeds of different crops, there is high percentage of moisture in the soil, which enhances soil fertility, and this condition is taken advantage of cultivating the entire area of arable land. In the subsequent season, some area is left fallow to recuperate the loss of nutrients in the summer cropping. The land that was covered by Finger millet crop is often left fallow in the next season. Area left fallow in the winter season is about 22 percent (Table 6.6). This area regains much of its fertility for cropping in the next season.

Area under pulses and oilseeds shown here is the one under pure crops.

Finger millet as the base crop is intermixed with pulses and amaranth and buckwheat.

Amaranth as the base crop is intercropped with kidney beans.

Most of the area under wheat is mixed with lentil, mustard and rapeseed. Among all the crops raised during the year, it is wheat that occupies the largest area (60 percent). Almost entire irrigated cropland and a sizeable upland area is covered by wheat. Most of the wheat in upland areas is intercropped with lentil and/ or mustard or rapeseed. Wheat in the lower irrigated cropland is raised as monoculture. Nearly 14 percent upland area is exclusively under lentil and equal area under oilseeds (mustard and rapeseed). Vegetables occupy only about five percent area (Table 6. 6).

Cropping intensity is low (178 percent) which is due to raising only two crops during the entire year and some cropland area left fallow during winter season. The cropping intensity is reflective of the use of agricultural land in an area. Higher intensity is obviously linked with higher amount of production. At the same time, however, it is reflective of higher amount of the nutrients drained from the soil and subsequently of poor fertility status of the soil. Lower cropping intensity is indicative of just the reverse.

Crop Rotations and Cropping Patterns

Rice-wheat rotation occupies much of the irrigated cropland area. Vegetable crops, like potato, onion, tomato, brinjal, and chillies are also raised in lower valleys at small scale. Crop rotations in irrigated land are as follows.

Crop Rotations in Irrigated Land: Crop rotations operationalised in the irrigated land are quite uniform. The same crops would enter into the same area every year. There is high degree of probability that the same varieties of the crop would be sown every year. However, there are some minor crop rotations in which different crops and their different varieties would appear at small scale. The main major and minor crop rotations occurring in the irrigated area are as follows.

Major: Rice-Wheat
Minor: Rice-Rapeseed-Potato
Rice-Potato-Potato
Chillies-Onion
Chillies-Wheat
Soybeans-Chillies-Radish
Rice-Onion

Crop Rotations in Upland Area: The cropping pattern in the upland area is amazingly diversified as against the uniformity maintained in the major crop rotation in the irrigated land. Large number of crops – cereals, pulses, oilseeds, pseudocereals, and vegetables – with very broad genetic base of each crop and mixed cropping pattern are some of the specificities of rainfed crop rotations. Sturdiness of germplasm is another specificity. Cropping patterns observed are as follows.

Major: Rice-Wheat
Mandua-Fallow
Mandua-Wheat
Jhangora-Wheat
Jhangora-Lentil
Pulses-Wheat
Mandua-Fallow-Jhangora
Mandua-Barley-Jhangora
Mandua-Lentil-Jhangora
Mandua-Fallow-Rice
Amaranth-Fallow-Jhangora
Amaranth-Rapeseed-Fallow
Minor: Jhangora-Mustard
Pigeonpea-Wheat
Rice-Potato
Tomato-Barley
Frenchbean-Pea
Sesamum-Wheat
Tomato-Cabbage
Wheat-Fallow-Potato
Potato-Rapeseed-Fallow
Frenchbean-Rapeseed-Fallow
Potato-Pea-Potato
Potato-Pea-Rapeseed

Mandua cropping pattern is unique in itself. This base crop is intercropped with many other crops. The important combinations and approximate area covered by each combination are given in Table 6.7.

The most important combination is mandua-amaranth that covers about 50 percent of the area devoted to this culture. Next in importance is the mandua-black gram combination occupying about 20 percent of the mandua farming. About eight percent area under mandua is intermixed with horse gram and six percent with amaranth and French beans together. About five percent of the total mandua

Table 6.7: Mandua-based Cropping Pattern in Jardhargaon

Madua (Finger Millet) + Other Crop	Area covered (Percent)
Mandua + Amaranth	50
Mandua + Black gram	20
Mandua + Horse gram	8
Mandua + Amaranth + French beans	6
Mandua + Rice bean	5
Mandua + Black soybean (*Bhat*)	4
Mandua + Buckwheat	2
Mandua + Green gram	2
Mandua + Cow pea	1
Mandua + Any above crop + Cleome (*Jakhia*)	1
Mandua + Any above crop + Sorghum (*Junala*)	0.5
Mandua + Any above crop + Foxtail millet	0.5

farming is done with rice bean and four percent with the local black soybean, bhat. Buckwheat and green gram occupy only two percent area each along with mandua. Cowpea is given about one percent area along with mandua. Cleome (jakhia) is not sown. It occurs only wild, but is maintained along with mandua. Cleome and junala, the Sorghum spp. each occupies only some half percent area with mandua as the base crop (Table 6.7). Importance of each alley crop would change from place to place and as per the needs of the farming community. Mandua-based cropping pattern reflects the unique synergy in mountain agriculture.

Thus, there are 12 patterns of mandua-based farming. Mandua-based farming is locally known as *baranaaja*, since there are 12 food grains raised along with mandua (*baranaaja* literally means 12 food grains). In some areas of the Central Himalayas, nevertheless, there are more than 12 combinations. In Dwarahat Block of Almora district in Kumaon region, groundnuts are also raised along with mandua. In many other places, soybeans, the introduced crop, are also raised along with mandua. Foxtail millet, or the Italian millet, is often intermixed with jhangora, the barnyard millet, but also with mandua.

The *baranaaja* culture thus harbours a large number of valuable genetic resources. This is the unique characteristic of mountain agriculture the local farmers are very much proud of. This culture needs to be saved against the onslaught of modern agriculture, i.e., the expanding soybeans everywhere in mountain areas. The introduced white-seeded soybeans are being propagated at the cost of *baranaaja*. This culture needs to be conserved and further ameliorated as a vital symbol of mountain agriculture.

Amaranth is generally sown with mandua. However, on higher altitudes, it is also cultivated as a dominant crop intercropped with French beans/ kidney beans and sometimes with other pulses. Amaranth can thrive well in poor, degraded, acidic, and/ or gravelly soils.

In *danda*, or summer camps in upper areas, where some villagers shift bag and baggage during summer, the main cropping patterns are:

Potato – Rapeseed – Fallow
Wheat – Fallow – Potato
Potato – Pea – Potato
Amaranth – Rapeseed – Fallow
Amaranth + French beans/
Kidney beans – Rapeseed – Fallow
Buckwheat – Rapeseed – Fallow

Potato and peas in the area are recent developments that have taken place in mountain agriculture. In some areas, e.g., in the Chamba-Mussoorie Fruit Belt, almost entire area at high altitudes has been transformed into vegetables. In other areas, transformation is at low pace and traditional crops are maintaining their place in local agriculture.

Farmers in Jardhargaon relate that in the past as much as 50 percent of the land was left fallow in winter season. With the demographic pressure on land, extent of fallowing has gone on reducing. The main rationale behind fallowing practices is:

i) it gives periodic chance to the land for convalescence;
ii) it restores and maintains soil fertility by preventing continuous drainage of soil nutrients, helping rotting of crop roots to convert them into organic culture for soil microbes;
iii) fallow land is used for grazing by village animals and thus it helps in-situ fertilization of the land; and
iv) it makes the ploughing operation easier.

Presence of forests in the farming system, according to the farmers, also favoured the fallowing practice, because extracting foods from the forest ecosystems compensates shortage of food to some extent. This is proven from the fact that in Henwal Valley where natural forests still exist in good condition, fallowing practice is still continuing as opposed to parts in the Bhagirathi Valley where fallowing practice is vanishing with the shrinkage of forest support system (Singh 1992).

Crop Productivity and Production

Productivity, straw-grain ratios, and production performance of the food grain crops are shown in Table 6.8. These figures are based on our own experiments in Jardhargaon. Figures for straw yields and straw production are based on straw-grain ratios assessed in the village. Figures for straw are important, for this feed resource is vital for livestock in the region.

The highest productivity is that of rice (24.70 q per ha) followed by wheat and barley (17 q per ha each). Yields of these crops depend on individual varieties, type of land and soil, cultural practices (including input use) and environmental factors.

Perusal of Table 6.8 reveals that it is the wheat that is produced in the largest quantity in the village (2380 q), followed by rice (1507 q) and mandua (1198 q). Summer pulses too have good share (468 q) in the total food grains. However, lentil sown in winter is the single pulse that is produced in the largest amount (404 q) of all the pulses.

All the food grains produced are not consumed directly by the local people. Almost all produce of amaranth and buckwheat is bartered against wheat and/ or rice and common salt. In this bartering, the two pseudo-cereals fetch equal amount of cereals and four times the salt. Rarely other non-consumable items usable at home are also fetched through bartering. An estimated 90 percent of the produce of pseudo-cereals is bartered against wheat and rice. Collected by the local shopkeepers, amaranth and buckwheat are exported to the plains.

Barley too is not consumed by the farmers directly. It is fed to livestock as concentrate almost exclusively. Rapeseed and mustard are consumed in the form of oil.

All the crop residues (straws) shown in Table 6.8 are fed to the livestock. Total amount of fodder produced in the village was 10421 q per year. Straw production depends upon productivity, area of cultivation, and straw-grain ratio of the crop. Highest amount of straw comes from wheat (32 percent) followed by from mandua (23 percent), rice (19 percent), jhangora (15 percent), pulses including lentil (8 percent), and barley (3 percent).

Livestock: Population, Composition and Performance

In Table 6.9 are given data on livestock population and herd structure. Buffaloes and cattle are the main livestock in the village, which are reared for milk production and draught power, respectively. Some families also maintain small to large number of goats.

Table 6.8: Productivity and Production Performance in Mountain Agriculture

Crop	Productivity (q/ ha)	Straw-Grain Ratios	Straw Yield (q/ ha)	Food grain Production in the Village (q)	Straw Production in the Village (q)
Rice	24.70	1.28	31.62	1506.70	1928.58
Mandua	14.98	2.00	29.96	1198.40	2396.80
Jhangora	11.08	2.80	31.02	565.08	1582.22
Amaranth	10.07	-	-	201.40	-
Buckwheat	6.35	-	-	64.52	-
Pulses	10.00	1.00	10.00	468.00	468.00
Wheat	17.00	1.38	23.46	2380.00	3284.40
Barley	17.00	1.50	25.50	238.00	357.00
Lentil	8.24	1.00	8.24	403.76	403.76
Rapeseed	9.75	-	-	39.00	-
Mustard	4.75	-	-	19.00	-

Note: Production figures for amaranth, buckwheat, summer pulses and lentil (winter pulse) have been adjusted according to the cropping pattern. For example, amaranth is cultivated as a dominant crop and as an intercrop. In the first case, its productivity is multiplied by its average area; in the latter, its productivity has been considered half and then multiplied by the average intercropped area. Same adjustments have been made for obtaining production figures for summer pulses that are cultivated as pure as well as intercropped with mandua. Winter pulse lentil is sown as pure crop as well as intermixed with 50 percent of the rain-fed wheat. When raised along with wheat the productivity of lentil is considered just half.

Goat is reared for milk and also serves as cash animal. Villagers also own a sizable number of sheep. Sheep has been a preferred ovine in the temperate area for the purpose of wool production. Ponies and mules serve as carry-pack animals.

Table 6.9: Population and Composition of Differ rent Classes of Livestock in Jardhargaon

Livestock	Population (No.)	Composition (%)
Cows	12	1.54
Bullocks	100	12.80
Buffaloes	500	64.02
Sheep	40	5.12
Goats	100	12.80
Ponies and Mules	29	3.71
Poultry Birds	60	-
Total	781	100

Note: Only large animals, not poultry birds, have been summed up.

Buffaloes constitute the largest percentage in the herd (64 percent). It is indicative of the fact that livestock composition is largely to serve milk production. Buffalo is the preferred milch species. Cows are kept mainly for producing bullocks for draught power supplies to agriculture. Cattle population over the years has decreased considerably, whereas that of buffaloes has witnessed a spurt in its population. Sheep population has also decreased, but that of goats has increased significantly over the years in Central Himalayas (Singh 2000). Jardhargaon is no exception.

Milk production performance of cows and buffaloes and wool production data have been portrayed in Table 6.10. Buffaloes produce more milk than the cows. In the total milk pool of the village, buffalo milk production contribution is as large as 98 percent. This is as a result of 16 times more population of buffaloes than of cows and higher milk production potential inherent in buffaloes.

Forestry

Forestry plays a key role in mountain agriculture. A larger forest-cropland ratio would favour agricultural sustainability. Jardhargaon has large area under the reserve forest towards the upper reaches of the village. Area under this forest is more than 10 km^2, but the forest is not exclusively of the village. It is shared by more than 10 villages around. The Reserve forest belongs to the Forest Department. However, the villagers have been provided right to collect firewood and fodder from the forest. This forest is dominated by the oak (*Quercus leucotrichophora*) species. The forest is in good condition thanks to the efforts of the villagers and is used to collect not only fodder and bedding material for livestock, but also edible wild fruits, flowers, honey, etc. and vegetables growing wild there. The forest harbours enormous biodiversity, including wild life. This dense forest area provides origin to water sources for many villages.

Table 6.10: Average Milk and Wool Production in Jardhargon

Item	Cow	Buffalo	Sheep
Milk Production			
Litres/ day/ head	2.0	5.0	-
Litres/ lactation/ head[1]	600.0	2700.0	-
Litres/ day in the village[2]	12.0	615.0	-
Litres/ day/ family[3]	0.04	2.12	-
Wool Production			
Kg/ year/ head	-	-	0.8
Kg/ year in the village[4]	-	-	32.0
Kg/ year/ family	-	-	0.11

[1]Lactation length of cow and buffalo was 300 and 540 days, respectively. To obtain milk production during entire lactation length, the per day/ head figures are multiplied by the lactation length for cow and buffalo in milk.

[2]Figures have been derived on the basis of the numbers of animals in lactation stage. These numbers have been multiplied by per day/ head milk production for cow and buffalo milk, respectively.

[3]To obtain milk production at family level, per day/ village milk production figures are divided by number of families in the village.

[4]Figures of wool production for the village have been obtained by multiplying the wool yield/ year/ head by total number of sheep in the village.

The other category of forests is that of commons. There are Civil-Soyam and Panchayat Forests. Covering an area of about 800 ha, three other villages of the Jardhargaon Gramsabha also share these common forests. Villagers themselves manage the commons. The commons are of thin to moderate density forests. These forests are mostly covered by pine (*Pinus roxburghii*) species. Broad-leaved species are also occurring sporadically. In recent years, villagers have planted a variety of multipurpose broad-leaved trees amidst the pine forests. The pine monocultures, as a result, are now converting into heterogeneous flora. A piece of the Panchayat forest land is left for growing grasses that are cut annually and distributed equally amongst the families of the village. All people of the village have rights to collect fodder and firewood from the commons and graze their animals there. Whenever in need, the villagers can request the Gram Panchayat for cutting a tree for timber and for extracting stones to be used for house construction.

Biodiversity

Agroecosystems with many different niches occupied by many different kinds of species and their genotypes are highly stable and give the farmers more security. This is the principle mountain farmers stick to to minimise risks and increase the level of their food security. They always tend to use as high number of useful plant species as can thrive in a particular farming situation. They also maintain functional diversity, achievable through combining complementary plant and animal species in synergetic interactions, which is one of the means to inject sustainability into the agroecosystems. Each plant species has very broad base of genetic diversity. A spectrum of plant species' biodiversity as maintained in the commons and cultivated in the arable land by the farmers in the Henwal Valley in Garhwal area of Uttaranchal is shown in Tables 6.11 and 6.12.

"Diversity is prosperity" is a traditional adage in the mountains. *Baranaaja* culture raised by marginality-ridden farmers is a unique testimony of it. *Baranaaja* literally means twelve foodgrains intercropped with finger millet as the base crop. Amaranth, buckwheat, kidney beans, horse gram, black soybean, black gram, green gram, cowpea, rice bean, adzuki bean, sorghum, and cleome are the main crops intermixed with finger millet. In some areas even groundnuts are also mixed with the base crop.

Baranaaja provides a unique example of how a mountain farmer cultivates biodiversity. This management helps provide the maximum number of food items ensuring balanced diet from the minimum area of land. This also represents one of the key points of the strategies involving nutrient management in the system that cares human nutrition as well as health of the ecosystem.

Diversity-laden agriculture is the best bet for reducing risks and enhancing the degree of security. The gains accrued to the farmers through diversified agriculture, however, are limited by the size of the arable land they own. But, it is not the arable land alone that could serve as the base for food security as is perceived in the context of the plains. Farmers in the mountains give equal, rather greater, importance to the CPRs, other marginal ecosystems (alpine meadows, for example), and water sources.

CPRs are often appreciated for their contribution to the community of fuel, fodder, and timber. That

Table 6.11: Plants of Different Consumptive Use Values in the Commons of the Central Himalayas
(A Case of Jardhargaon in the Henwal Valley)

Edible Fruits, Flowers, and Buds	Benthamida capitata, Myrica esculenta, Ficus auriculata, F. palmate, Bauhinia purpurea, Morus serrata, Celtis australis, Indigofera gerardiana, Phyllanthus emblica, Rhododendron arboreum, Aesculus indica, Rubus ellipticus, R. lasiocarpus, Pyrus pashia, P. lanata, fragaria vesca, Pyracantha crenulata, Grewia sapida, Holboellia latifolia, Bombax sp., Debregeasia longifolia, Carissa opaca, Elaeagnus parviflora, Pirus gerardiana.
Wild Vegetables	Diplazium frondosum, Utrica ardens, Chenopodium album, diascorea belophylla, D. bulbifera, Solena amplexicaulis, Nasturtium officinale, flemingia procumbens, fagopyrum dibotris, Bombax sp., Indigofera gerardiana, Celtis australis, Kholya or Sisua (local name), mushrooms.
Leaf Fodder	Adina cardifloia, Aesculus indica, Artocarpus lakoocha, Bassia butyraceae, Bauhinia purpurea, B. vahlii, B. variegata, Boehmeria platyphylla, B. rugulosa, Brassiopsis hainla, Budleja asiatica, castanopsis hystrix, C. indica, C. tribuoides, Celtis australis, Choerospondias axillaries, Debregeasia salicifolia, Erythrena arborescens, Eurya acuminata, Ficus auriculata, F. fabberrima, F. infectoria, F. neriifoli, F. religiosa, F. semicordata, F. subincisa, Geruga pinnata, Grewia optiva, Helectecteres isora, Holmskioldia sanguinea, Kydea calycena, Lespediza eriopcarpa, Lithocarpus elegans, Litsea monopetala, mallotus philippensis, Maoutia putya, melia azedarach, Melletia auriculata, Morus alba, myrsina capitellata, Porana paniculata, Premna latifolia, prunus armeniaca, p. ssrasoides, Pterespermus acerifolium, Quercus glauca, Q. lamellose, Q. lanata, Q. leucotrichofolia, Q. semecarpifolia, Spermedictyon suaveolens, Woorfordia fruticosa.

Source: Singh, V. (2001).

Note: Apart from the above, there are more than hundred medicinal and aromatic plants occurring in mountain ecosystems that are utilised by the people in Uttaranchal Himalayas, India.

Table 6.12: Plant Species' Diversity Cultivated by Farmers in the Henwal Valley of Central Himalayas

Cultivated Fruits	Prunus armeniaca, P. amygdalus, P. domestica, P. avium, P. persica, Malus pumila, Juglans regia, Pyrus communis, Citrus reticulata, C. sininsis, C. aurantifolia, C. limon, C. medica, Mangifera indica, Aegle marmedos, Musa paradisiacal, Litchi sinensis, Embilica officinalis.
Cultivated Vegetables	Solanum tuberosum, S. melongena, S. lycopersicum, Capsicum annum, C. frutiescence, Colocasia esculenta, Alocasia macrorrhiza, Cucurbita pepo, C. moschata, Langenaria, sinceraria, Luffa acutangula, L. aegyptiaca, Trichosanthes anguina, Cucumis sativus, Raphanus sativus, Spinacia oleracia, Momordica charantia, M. dioca, Daucus carota, Pisum sativum, Lablab perpureus, Amaranthus sp., Fagopyrum sp., Beta juncea, B. oleracea, B. rapa, Trigonella foenumgraecum, B. vulgaris, Allium cepa, A. sativum, Vicia faba, Phaseolus vulgaris.
Cereals, Millets, and Pseudocereals	Oryza sativa, Triticum aestivum, Hordeum vulgare, Zea mays, Sorghum sp., Pennisetum typhoides, Eleucine coracana, Echinochloa frumentacea, Setaria etalica, Panicum millaceum, Amaranthus sp., Fagopyrum sp.
Pulses	Glycine max, Vigna mungo, Macrotyloma uniflorum, Vigna umbellate, V. angularis, V. radiata, Phaseolus vulgaris, Cajanus cajan, Lense culinaris, Cicer arietinum.
Oilseeds	Brassica juncea, B. campestris, B. napus, Sesamum indicum, Arachis hypogea, Helianthus annuus, Perilla frutescence.
Spices	Zinger officinale, Curcuma domestica, Coriandrum sativum, Ammomum oramaticum, Trigonella foenumgraecum, Cleome viscosa.

Source: Singh, Vir (2001).

they can provide the most basic necessity of humans, i.e., a variety of food items, is seldom appreciated. Vital role of uncultivated forest areas for providing different food items to the community is evident from the example of the Henwal Valley of Garhwal in Uttaranchal Mountains. In this Valley as many as 189 different naturally occurring species of plants offer edible products while people cultivate only 92 different food-producing plants on their cultivated land. Comparing this scenario with that of the plains' agriculture in the adjoining areas of the Garhwal Mountains, we would find that farmers depend only on 33 plant species for their survival. Thus, from the point of view of plant species' diversity offering food articles, CPRs are the richest sources (Table 6.13).

Table 6.13: Number of Plant Species Providing Food in the Mountain Ecosystems and the Plains' Agriculture

Food Item	Mountain Ecosystems*		Plains'
	CPRs	Cropland	Agriculture**
Fruits	24	18	6
Vegetables	14	32	10
Cereals, Millets & Pseudocereals	-	12	4
Pulses	-	10	5
Oilseeds	-	7	4
Medicinal & Aromatic Plants	99	4	-
Fodder***	52	9	-
Total Species	189	92	33

Source: Singh (2001).

** Figures are based on a survey of Henwal Valley in the Garhwal area of the Uttaranchal Mountains.*

*** Figures are based on a survey of the plains adjoining Garhwal.*

**** Livestock convert this forest biomass into human food, e.g., milk.*

Each food plant species has a very broad genetic base. Farmers cultivate an appreciably large number of varieties or landraces of every crop. Himalayan valleys of Uttaranchal are especially famous for a variety of rice landraces, each with specific traits. Traditional rice varieties, like Hansraj, Ramjawan, Kanguri, Bangway, Gorakhpuri, Basmati, Thapachini, Jhumkya, etc., thrive in lowland valley areas, while Chawaria, Munjil, Jhailda, Lekmal, Kallao, Almunji, Chwatu, etc., grow well in upland rainfed areas and at high altitudes. Some landraces can be grown even close to glaciers. Some landraces demand more water, some less, and some need no irrigation at all. Productivity of rainfed varieties is comparable with those of irrigated ones. Such rare, hardy, and sturdy varieties would hardly be found in the plain areas anywhere in the world.

Mountain farmers rear all types of animals – draught animals, carry-pack animals, milch animals, wool animals, meat animals, poultry birds, rabbits, etc. – that are suitable for the farming systems. Functional diversity, mountain farmers achieve through combining complementary plant and animal species in synergetic interactions, injects sustainability into the agroecosystems. Livestock form the core of livelihood systems of livestock-dependent marginal mountain communities. They are not just an economic source, but are farmers' best companions serving them as manurers, exploiters of wastes, sources of power, forms of investments, and in many more ways. They form a cultural identity of mountain people. By transferring nutrients from forest ecosystem to farmlands and maintaining cyclic flow pattern in the farming systems, they contribute to the ecological integrity of the system (Singh 1998a, 2000; Tulachan 1998; Tulachan and Neupane 1999).

High degree of biodiversity creates barriers against any natural calamity (drought, for example) and pest epidemics. Some living organisms may be host to certain insects or diseases, some may be little more prone to weather extremes or other adverse conditions, but a complex mix of naturally occurring (in natural forest areas) organisms will do away any chances of widespread loss to the farmers. Marginal farmers in Uttaranchal would cultivate many-many different varieties for different purposes (productivity, drought resistance, taste, colour, nutritive value, rituals, etc.) and in doing so they enhance the degree of their security.

Gender

About 56 percent of the total population in Jardhargaon comprises female humans. This population composition dominated by females remains a rare scenario in India and is a reflective of greater care, role and demand of women in the society. However, women have to be at the forefront of struggles for life.

They constitute backbone of the land-based economy of the mountains. As the compulsion of cash economy is on the increase in mountain areas, most of the able-bodied males are bound to migrate from their native villages in search of jobs in non land-related activities to the urban areas in the plains. Under such circumstances, women are the de facto heads of their families. They, however, need not be mentally prepared to take on the tasks which traditionally meant to be taken by men, e.g., sale of their produce in the market, purchase of a costly item, animal, etc. for their family.

A male's job has virtually become to earn money to keep the family going. This dichotomy in the role of male and female in agriculture is, in fact, not customary, but is a recent phenomenon that has been strengthening with the intrusion of cash economy into the traditional land-based subsistence (though sustainable) economy in which biodiversity, culture, and purity of environment were regarded as the supreme principles of social prosperity and happiness and in which there was a unique gender collaboration. The gradual breakdown of this natural collaboration has put women folk into drudgery.

The biodiversity-rich traditional farming systems are gender-sensitive. Almost all farm operations are carried out by the knowledge, skills, philosophies, and energy of women. Only the operations, such as ploughing, levelling, and puddling, in which animals' energy is shared, are carried out by men. However, women farmers also assist these operations. For examples, when, bullocks till the fields, women would break the clods to prepare the fields for sowing; when levelling of the fields is done, women would level the corners left; when men yoke the bullocks for puddling, women would do the same by their own hands behind the puddler to prepare the fields more efficiently for rice transplantation; and when animals are made trample the harvest for threshing, they would be driven by women. The other agricultural operations – like, applications of manure in the fields, sowing, transplanting, weeding, interculture, harvesting, and all post-harvest ones – are done exclusively by women. Women also accomplish all activities relating to animal husbandry and forestry. These laborious and back-breaking jobs are apart from their crucial responsibilities at home front.

Women farmers are especially conscious about biodiversity conservation. Cultivation of landraces is the core process of their biodiversity conservation. Jardhargaon, thanks to the efforts of women folk, has more than 300 landraces of rice. These once had vanished due to large-scale intervention of institutional programmes emphasizing the so-called fewer HYVs. Seeing the bitter experiences of the HYVs' unsustainability, the women farmers re-introduced their landraces.

Rice cultivation is energy-intensive. It requires more animate energy than any other cereal crop in the mountains. More human labour is devoted per hectare cultivation of rice than any other cereal crop (Singh 1998a). Transplantation of rice is especially more labour demanding. In the absence of their male counterparts, female farmers manage most (virtually all) operations needed for rice cultivation. Overworking women often encounter the inevitable problems of overstress, drudgery, ill health, and the likes. They would be unable to devote as much time to their children and household chores as they should.

There might be certain degree of difference in the attitude of males and females with respect to rice cultivation. For instance, women are often in favour of the production systems relying on high level of valuable biodiversity, use of internal organic inputs, self-sufficiency, and ecological integrity of the system. Men, on the other hand, tend to be depending on external market for sale of produce and purchase of inputs and for this to happen, they won't hesitate compromising with local values. Jardhargaon, however, demonstrates high degree of gender collaboration. This village, being active in the Beej Bachao Andolan (Save Seed Movement), supports values women have been upholding for evolving sustainable society in complete harmony with nature. They hold reverential attitude towards nature and her all life forms, which is the way to ensure survival and sustainability.

Van Sanrakshan Samiti (Forest Conservation Committee) is active in Jardhargaon for last several years. The Committee comprises majority of women. This was constituted to regulate biotic pressure on the oak forest and keep pace with its ecological regeneration. Women do not use sickle to cut twigs and leaves of oak for fodder, only lopping by hands is allowed. Only dry twigs, not green, would be extracted for fuel from the forest. As a result of this community management, villagers are obtaining fuel wood, fodder, and wild foods from the forest area on sustained basis. The natural oak forest is in ecological balance and provides water sources to the villagers. Impact of this forest on farming is visible.

Conclusions

Traditional mountain agro-ecosystems have all the features essential for sustainable agriculture. They represent natural resource-centred farming and rely on zero or very low external inputs. The production system is based on the endemic biodiversity. Mountain farmers manage ecological niches for growing specific products and for specific functions. They derive their foods and livelihoods from the local biodiversity. Their approach is conservation-oriented and the agricultural system they have evolved is regenerative and ecologically sound.

The traditional agro-ecosystems are nature-subsidised solar-powered ecosystems that are energy-efficient. The system exhibits enormous diversity-complexity in which output of one function becomes input for the other. There is intensive cycling and recycling of nutrients in the system. Forests are the key to maintain ecological integrity of the system. Livestock-mediated flows of nutrients are vital for the maintenance of sustainability of the agro-ecosystems.

Traditional farmers' wisdom, skills, and strategies used in the biodiversity-based food production system outperform the modern scientific techniques used in the Green Revolution type of production systems. Farmers' values, traditions, culture, history of mountain agriculture, local perspectives, changing circumstances, and holistic world view all are the elements farmers' wisdom and strategies embrace and keep the whole system in a dynamic state.

Women are the pivotal force of agriculture. They have enormous responsibilities at various fronts of livelihoods. They are also the major decision-makers in the traditional systems not linked with market. Gender-equity is higher in the traditional systems than in the modern or transformed ones.

The traditional agro-ecosystems do not operate in cash economy. However, farming communities inhabiting these ecosystems, grow many unique products on which mountains have monopoly. If these products were linked with the market system, they could fetch handsome returns to the mountain farmers. There seems to be enormous scope of mountain products derivable from the endemic diversity in future.

7

Case Studies: Transformed Agro-ecosystems

The Concept of "Ecology of Action": Here is where the notion of the ecology of action intervenes. The moment an individual undertakes an action, whatever it may be, it starts to escape her/his intentions. The action enters a universe of interaction and it is finally the environment that takes possession over it, possibly changing its course into one contrary to the original intention.

– Edgardo Morin

For sustainable agriculture, increasingly uniform crops may be more vulnerable to pests and diseases.

– Dhruva Joshy (2000)

Previously, the kind of variety we used to cultivate was tastier, compared to the modern varieties. It was also not a source of disease: it did not contain any pesticide or pesticide residues. After consuming these new rice varieties, we are now suffering from many diseases, so there are health problems along with the other problems. There are health problems in the livestock and poultry also, so the management of livestock and poultry is more difficult now.

– Raksya Begum, woman farmer from Bangladesh (2001)

In this environment where everything is being privatized, the only things being socialized – shared publicly – are social and environmental costs.

– Camila Montecinos (2002)

I. A Village in the Bhagirathi Valley

Kandhla Badethi is a village in the district of Uttarkashi. Situated at an altitude of 1200 m from mean sea level, this village has undergone considerable transformation, particularly in terms of genetic transformation. Agricultural land in the village is flat, mostly irrigated and with fertile soil. The village is situated on main road-side and is well linked with the market system. Nearby, in Chinyalisaur, is located a government agricultural farm that distributes the so-called HYVs of seeds and is a powerful engine of agricultural transformation in the villages of the valley villages along the Bhagirathi river.

Demographic Features

There were some 62 families in the village with a total population of 737. The population comprised 29.44 per cent adult males, 31.07 per cent adult females, 21.46 male children, and 30.90 female children. Family size, thus, was slightly higher, 11.89 persons per family. A sizeable population of the village, particularly comprising adult males of potential age group are working outside the region.

Common Property Resources

The village shares some 25 ha (1250 *Nalis*) community land which is the main common property resource (CPR) in the village. Residents of the village have right on the produce of CPRs. The scenario of the CPRs, however, is dismal. There are only thin stands of trees on the land with large area under degraded land. Owing to entire emphasis on the transformation of agriculture and continuous negligence of a farming system approach, the CPRs are left out of development planning and programmes.

The vegetation is mostly of pines that provide only fuel wood. There are no species providing wild fruits and other edibles from CPRs as would be expected in the villages that have given adequate attention towards the management of their CPRs. The Panchayat body of the Gramsabha Kandhla Badethi falls in is also somewhat neutral towards the CPRs. Villagers' entire focus is on cropland due to excessive external intervention. The farmers have been led to think that they can improve their economic conditions by changing their cropping systems with incorporation of fertilizer-responsive HYVs of crops. The cropland/

cultivated land is the only target of management. Its linkages with CPRs have been broken down. This, of course, is the malady with the conventional institution-led agricultural transformation.

Area under Cropland

The total cropland area in the village is 78 ha out of which as much as 59 per cent is irrigated. The average holding size (cropland per family) is little over 1.26 ha (Table 7.1). The most important characteristic of the cultivated land is that it is largely irrigated. In mountain areas, cropland under irrigation is about 10 per cent. From this point of view, it could be inferred that irrigated area in the study village is much higher. And this is the major reason of agricultural transformation in the village. The irrigation potential has been possible to harness due the strategic situation of the village.

Table 7.1: Cropland Area in Village Kandhla Badethi, ha (*nails*)

Total Cropland	78.00 (3900)
Irrigated	46.00 (2300)
Unirrigated	32.00 (1600)
Percentage of Irrigated land	58.97
Cropland per Family	1.26 (63)

Note: Nali *is the local unit of land area measurement. One* nali *is equal to 200* m^2

As many as 16 per cent of the total holdings are marginal, i.e., have less than or equal to 0.5 ha cultivated land. Some 26 per cent holdings are of small size (less than or equal to 1.0 ha land) and 50 per cent of medium size (less than or equal to 2.0 ha land). Holdings with more than 2.0 ha land are only eight per cent.

The soils in the Bhagirathi valley are very fertile. Despite use of chemical fertilizers, farmers apply manure/ compost in their fields on regular basis, before the sowing of a crop. Livestock are still the source of draught power and they are likely to stay for a long time despite large-scale commercialization of farming. However, the adjoining village of Chinyalisaur has witnessed use of tractor on its government farm. Tractorisation of mountain agriculture that could be feasible only in valley areas, would badly affect the fertility status of the soil, apart from creating many other socioeconomic and environmental problems (Singh 1998a), by delinking livestock from the cropland.

Cropping Pattern

Cropping pattern (area devoted to individual crop and cropping intensity) in the agriculturally transformed village is presented in Table 7.2. There are two crop seasons, namely, summer or Kharif and winter or Rabi. The crops cultivated in these two seasons are different.

Amongst the summer crops, it is lowland rice that occupies the largest area, followed by vegetables. Almost all the varieties of these crops are the fertilizer-responsive HYVs. The millets and pulses are cultivated in the upland irrigated areas. The crop varieties sown in upland rain-fed areas are mostly local. Area under millet crops and pulses has declined considerably in recent years. Soy bean is an introduced crop. This has largely replaced the millets and local pulses. People do not incorporate soy bean in their food habits. It is sown solely for sale in the market.

Amongst the winter crops, lowland (irrigated) wheat occupies the largest area, followed by the upland (rain-fed) wheat and vegetables. Wheat, thus, is the crop that occupies the largest area in the village.

Table 7.2: Crop Area (ha) of all Households and its Distribution as a Percentage of Cultivated Area in Village Kandhla Badethi

Crop	Area under Crop	Percentage of Cultivated Area
Summer Crops		
Upland Rice	4.50	2.88
Lowland Rice	30.00	19.23
Finger Millet + Pulses	8.50	5.45
Barnyard Millet	11.00	7.05
Soybean	6.00	3.85
Oilseeds	2.00	1.28
Vegetables	16.00	10.26
Winter Crops		
Upland Wheat	22.50	14.42
Lowland Wheat	30.50	19.56
Pulses	3.50	2.24
Oilseeds	6.00	3.85
Vegetables	15.50	9.94
Total Cultivated Area	156.00	100
Total Cropland	78.00	-
Cropping Intensity, %	200.00	-

All the wheat varieties in lowland are HYVs, whereas the upland area is broadcast only with the local varieties that are hardy and thrive well even in drought/ unfavourable conditions. Pulses, mainly lentil, are not cultivated on sizeable area.

The cropping intensity, thus, is 200 per cent, which is quite impressive compared to one in the traditional system of cropping as we have already noted. The relatively high cropping intensity in transformed areas is due to more intensive use of cultivated land (Table 7.2).

Crop Productivity

Productivity of different crops raised in the study village is presented in Table 7.3. Productivity has been divided into main product that is consumable by human beings and the by-product that has fodder value for livestock. The latter is important in mountain context as the mountain agriculture is livestock-dependent and livestock have to be the partners in agriculture. Soybean, oilseeds, and vegetables do not provide fodder to livestock. Maximum output per ha is that of vegetables. Amongst the food grain crops, wheat and rice yield the highest amount of main products. Yields of finger millet-based crops are higher than soybean. Soybean substitutes the finger millet-based cropping pattern. Moreover, soybean has nothing to provide to livestock as its stalks are discarded, unlike those of other pulses the stalks of which provide valuable fodder.

Table 7.3: Average Productivity (q/ha) of Different Crops at Study Sites

Crop	Main Product	By-Product
Summer Crops		
Upland Rice	22	29
Lowland Rice	35	45
Finger Millet + Pulses	16+7	32+7
Barnyard Millet	13	36
Soybean	16	-
Oilseeds	5	-
Vegetables (+Potatoes)	56+80*	-
Winter Crops		
Upland Wheat	23	29
Lowland Wheat	37	49
Pulses	10	10
Oilseeds	5	-
Vegetables (+Potatoes)	58+80*	-

Livestock

Bovine-dominated herds are found in the agriculturally transformed villages. The village has more number of buffaloes (45 per cent) rather than cattle, as would generally be expected in a traditional village. Among the cattle, bullocks accounted for 32 percent (Table 7.4).

Average livestock holding size in the village was 3.89, which was equal to 3.98 cattle units. This comprised 3.29 bovine (buffaloes and cattle) and only 0.48 ovine. There were 1.53 cattle against 1.76 buffaloes per household. She-buffaloes were many times more than cows. There was less than half a goat per household, but no sheep in the village. (Table 7.4).

Table 7.4: Population of Different Classes of Livestock in the Agriculturally Transformed Village

Livestock Species	Village	Per Household
A. Bovine	204 (84.65)	3.29
a. Cattle	95 (39.42)	1.53
i. Bullocks	77 (31.95)	1.24
ii. Cows	9 (3.73)	0.15
iii. Male Calves	4 (1.66)	0.06
iv. Female Calves	5 (2.07)	0.08
b. Buffaloes	109 (45.23)	1.76
i. She-buffaloes	62 (25.73)	1.00
ii. Female Calves	47 (19.50)	0.76
B. Ovine	30 (12.45)	0.48
a. Goats	30 (12.45)	0.48
b. Sheep	-	-
C. Pack Animals	7 (2.90)	0.11
Total Population (A+B+C)	241 (100.00)	3.89
Total Cattle Units*	247	3.98

Figures in parentheses are percentages of the total livestock population.

**Conversion Factor (based on Singh 1998a): Cow=1.0, Bullock=1.2, Cow Calf=0.5, Buffalo=1.5, Buffalo calf=0.75, Goat=0.2, Sheep=0.2, Carry pack animal=1.0.*

The livestock composition in the transformed village suggests that there is more emphasis on buffaloes for milk production. Buffalo milk has higher fat value and fetches more incomes for families.

Numbers of bullocks per household were only 1.24. The situation of less than two bullocks per family suggests some other arrangement for the supplies of draught power for the preparation of land. There was no sharing of bullocks for ploughing.

Intensity of hiring-in of plough was very high as the transformed agriculture required more draught animal power for cultivation of crops, as is also revealed by Singh (1998a).

Gender and Technology

Transformation in agriculture alters gender relationships with agriculture. Women in traditional setting are rich sources of knowledge about agriculture. Not only are they the mistresses of all agricultural practices, they are also agro-ecophilosophers. They regard agriculture as part and parcel of life rather than just an economic activity. All traditional agricultural technologies right from sowing of seeds or transplantation to post harvesting are on their tips. They would value and rely on nature's biodiversity. Names of all varieties of cultivars, all the qualities and values associated with each variety of each crop and utilization of every variety are all under their command. Women, in essence, are the real farmers in the mountains. They are the backbone of traditional mountain agriculture.

Transformed agriculture in the mountains requires more human labour. Women's workload, therefore, increases significantly. Their role in this agriculture, however, is different than in the traditional agriculture. Land-related knowledge they have inherited from their ancestors is not of much use in this chemical-responsive agriculture. They generally won't like new varieties of seeds. Pressure of institutional extension and development agencies for transformation is so high that their male counterparts, the heads of families, have often to yield to such pressures and resort to replace local varieties with the so-called HYVs. Again, language of the R & D and extension workers is so seductive that farmers, including the women farmers, easily accept a new variety for cultivation.

Do they replace a local variety in just the first attempt after they are given a 'miracle' variety by an agency? No. They would experiment with the new variety they are going to introduce in their own way. First of all, they would replace only one-tenth of their area with the variety they intend to introduce. The rest of the area would be devoted to the old local variety. If the introduced variety is promising one, the farmers would increase its area the next year. If the introduced variety is up to their expectations, they would like to devote about 50 percent area to the introduced variety. Hundred percent replacements would take several years. In case there are some flaws with the introduced variety, the farmers would like to restrict cultivation area under that crop.

Sometimes farmers would apply their own technology even in case of HYVs. For example, instead of line sowing, they would apply broadcast method of seed sowing. In some instances, they would intermix the base HYV crop with some local crop.

The HYVs are often raised in monocultures. These are more vulnerable to various diseases and insect onslaughts. Therefore, HYVs, in addition to chemical fertilizers, also demand indiscriminate use of pesticides. These are also water-guzzling varieties. Irrigation frequency in case of rice and wheat increases when HYVs replace the local varieties. Bhagirathi valley in which the Kandhla Badethi village is situated has no dearth of irrigation facilities. This is one reason why HYVs have captured their roots in this valley.

Once a new variety occupies sizeable area, many cultural practices would change. A considerable decline in traditional knowledge system would be observed. Women farmers, mostly illiterate, would not understand the imported package of cultural practices. Even male farmers would not follow all the institutional recommendations necessary for obtaining potential yields from the 'miracle' varieties. External expertise would become necessary. And for this, a network of government departments, plant protection units, university extension system, etc. would always be ready.

Agricultural transformation makes farmers completely dependent on many external factors. The worst sufferers are the women farmers whose role is reduced to mere labourers. The new knowledge the HYVs require for cultivation is not at the command of women farmers. Their social status further declines and, in fact, the decline is proportional to the degree of HYV-led transformation.

II. A Village in the Apple belt of Garhwal

Chamba-Mussoorie Fruit Belt is well known and a prestigious area of apple production in Garhwal. This belt came into existence in June 1965. An area of about 5000 acres under dense natural mixed oak forests was earmarked for the Fruit Belt and destroyed to give place to apple cultivation at a massive scale.

The Fruit Belt was formally inaugurated by the late Mrs. Sucheta Kripalani, the then Chief Minister of Uttar Pradesh. The apple orchards started yielding fruits by the end of Seventies. Each year more and more natural forest area was replaced by apple orchards (Singh 1991).

Chaupariyalgaon is one of the several villages in the Fruit Belt. Situated at a height of about 2000 m from mean sea level, this village falls in the Henwal-Ganga catchment area. Horticulture-dominated farming is the life-line of the village. Earlier, only fruits – apples, almost exclusively – were the dominant produce of the land. In the long run, apple orchards have been diversified into vegetable cultivation. This village, like the other villages in the belt, is harnessing the unique ecological niches of the Himalayas for gainful employment and cash incomes.

Village Chaupariyalgaon has 140 families with a total population of 1400. Family size (10 persons per family) is fairly large. The village population comprises 30 per cent adult males and 20 per cent adult females. Percentage of male and female children is equal (25 each) (Table 7.5).

Table 7.5: Some Demographic Features of the Village

Particulars	Number (per cent of the total population)
Number of families	140
Total population	1400
Adult males	420 (30)
Adult females	280 (20)
Male children	350 (25)
Female children	350 (25)
Family size	10

Land Use in the Village

A sizeable area (50.00 ha) of land in the village is under commons. Most of the area of this uncultivated land is covered by oak forests. The common land/ community land is earmarked on the level of Gramsabha, a cluster of some three to five villages. Chaupariyalgaon's share is only 50.00 ha. Cultivated land area in the village is 105.00 ha. (Table 7.6).

About 65.00 ha of the cultivated area, i.e. about 62 per cent of the total cropland, is under apple orchards. Average holding size in the village is little less than one ha which is indicative of small holding size (Table 7.6).

Table 7.6: Community Land and Cropland Area in Chaupariyalgaon

Particulars	Area, ha (*nalis*)
Community land	50.00 (2500)
Cropland	105.00* (5250)
Cropland per family	0.75 (38)

Note: Nali *is the local unit of land measurement (1.0 ha = 50* nalis*).*

* *Includes 65.00 ha (3250* nalis*) under apple orchards.*

Cropping Pattern

Cropping pattern (area devoted to individual crop and cropping intensity) in the agriculturally transformed village is presented in Table 7.7. There is no irrigated land in the village. There is, therefore, no cultivation of lowland rice and lowland wheat. Area devoted to upland rice is meagre, lees than one per cent. Area under upland wheat, however, is about 10 per cent. Millet crops, unlike in traditional areas of agriculture, are not given much importance.

Table 7.7: Crop Area (ha) of all Households and its Distribution as a Percentage of Cultivated Area in Village Chaupariyalgaon

Crop	Area under Crop	Percentage of Cultivated Area
Summer Crops		
Upland Rice	1.60	0.95
Lowland Rice	0.00	0.00
Finger Millet + Pulses	8.67	5.14
Barnyard Millet	12.00	7.11
Soybean	2.40	1.42
Oilseeds	0.00	0.00
Vegetables	80.33*	47.58
Winter Crops		
Upland Wheat	16.33	9.67
Lowland Wheat	0.00	0.00
Pulses	3.75	2.22
Oilseeds	3.75	2.22
Vegetables	40.00**	23.69
Total Cultivated Area	168.83	100
Total Cropland	105.00	-
Cropping Intensity, %	160.79	-

* *65 ha area under apple orchards is included.*

** *32.5 ha area under vegetables lie in apple orchards.*

Little less than 50 per cent area of the cultivated land is devoted to vegetable cultivation during summer season. About 78 per cent of the total area under vegetable in summer season is in the apple orchards. Vegetable cultivation area during winter is only 24 per cent. More than 80 per cent of this area during winter is in the apple orchards. Cropping intensity, thus, is 161 per cent (Table 7.7).

Crop Productivity

Productivity figures of different crops are presented in Table 7.8. Main vegetables – French beans, pea, cabbage, etc. – are raised along with potato. Productivity of potatoes (87 q per ha) is higher than the main green vegetables (67 q per ha) in summer season. These figures for the winter crops differ non-significantly.

Vegetable crops, like soybeans, do not provide any by-product (fodder) for use by livestock. Transformed agriculture, particularly the horticulture-dominated agriculture, is not a livestock-friendly agriculture. In mountain areas, the by-products of the crops are very important, as they are critical for livestock feeding and thus for livestock husbandry without which there can be no sustainability of agriculture in the mountains. Commercial agriculture does not fulfill this condition. This has enormous repercussion on livestock population and composition.

Gender and Technology

Horticulture-dominated agriculture in mountain areas has so far emerged as gender-insensitive. This transformation has rather been a play of males. Being market-oriented, this agriculture has marginalised women's role as the backbone of mountain agriculture. There is no place for women's wisdom to be articulated in this sort of transformation. Their status is no more than that of labourers.

Women are involved from the plantation to the harvest of fruits. They would be seen tending saplings, transporting and applying manure, weeding and earthing-up and intercropping apple orchards.

In fruit season, large number of women (mostly the Nepali women labourers) in the Chamba-Mussoorie Fruit Belt would be found picking apple fruits from orchards, packing them in wooden cases and head-loading them to road heads. They would also be found loading them on the back of carry-pack animals and in trucks for transportation to market areas.

Table 7.8: Average Productivity (q/ha) of Different Crops at Study Sites

Crop	Main Product	By-Product
Summer Crops		
Upland Rice	18	27
Finger Millet + Pulses	15+7	30+7
Barnyard Millet	13	36
Soybean	18	-
Oilseeds	5	-
Vegetables	67+87*	-
Winter Crops		
Upland Wheat	24	29
Pulses	10	10
Oilseeds	5	-
Vegetables	65+85*	-

** Main green vegetables (Cabbage, French beans, Peas, etc.) + Potato*

Vegetable cultivation especially needs more bullock and human labour. Women have to devote lot of time and labour in vegetable cultivation. It is the weeding and earthing-up operation that consumes most of women's time and energy.

Use of human energy is inevitably linked with all agricultural operations carried out by draught animals, i.e. ploughing, levelling, puddling, weeding and threshing. Other operations – hand-weeding, irrigation, manure transport and application, breaking of clods, sowing and transplantation, fertilizer and pesticide application, harvesting and hand – threshing use only human energy. According to a study by Singh (1998a), amongst all types of agriculture – e.g., primitive type hand tool-based high Himalayan agriculture, traditional cereal-based, transitional cereal-based, genetically transformed cereal-based – it is the transformed horticulture-based agriculture that requires maximum bullock and human hours and energy (11696 hours and 1586 kWh) per ha per year.

It is again the horticulture-dominated agriculture that absorbs the maximum amount of chemical inputs (Singh 1998a). In Chaupariyalgaon, chemical fertilizers are applied at the rate of 300 kg per ha per annum. Pesticides are used at the rate of 75 kg per ha per annum. Use of these chemical inputs in traditional agriculture is almost negligible.

For external inputs, the transformed horticulture-based agriculture heavily depends on market system. This market-oriented agriculture is a preserve of males. As Reijntjes *et al.* (1992) rightly put it, "Western-trained researchers are usually imbued with

Western models of the division of labour between men and women, in which the men dominate the external economic domain and women the household domain." "This scenario", according to them, "inappropriate as it is even for industrial societies, has blinded researchers to the fact that women play a significant role in agriculture". As a result, the horticulture-dominated transformation relying heavily on market system has deprived the crucial role of mountain women in evolving suitable technologies and relevant strategies as they have been doing so for millennia. This sort of agriculture, thus, is gender-biased and not conducive to high social-cultural ethos of mountain areas.

8

Summary and Conclusion

You can't solve a problem on the same level on which it was created. You have to rise above it to the next level.

– *Albert Einstein*

Evolution has created a wonderful laboratory for itself in the bosom of nature.

– *Henryk Skolimowski*

Nowhere in the world can such a diversity of vegetation be seen as in the Himalayas.

– *W.J. Hooker*

The new South Asian woman is slowly but surely emerging as a strong force. The time is ripe for the emerging woman to take her rightful place in society. Women have much more power than they realise.

– *Mabelle Arole (1995)*

Women's crops are becoming marginalized, women are without excess to the new skills imparted to their men folk, and the base of biodiversity and the indigenous knowledge for maintaining it are being narrowed down without women understanding the process or its consequences.

– *P.K. Shrestha (1996)*

More than any other people in the world, mountain people still master the art of living in an ecological balance.

– *Hans Carlier (1996)*

Sensitivity on the part of policy-makers and natural resource managers is a sine qua non for balancing biodiversity conservation with local people's concerns.

– *Egbert Pelinck (1998)*

Perhaps due to difficulties in eking out a living in a harsh mountain environment, women from highland areas historically needed to participate in agriculture and natural resource management.

– *Jeannette Gurung (1998)*

Informed popular resistance to the theft of biodiversity, legitimized by the patenting of life forms, has now become part of a tidal wave of public opposition that is affecting, and will increasingly affect all of civil society.

– *Erna Bennett (2002)*

This book is focusing on the values of biodiversity in the agro-ecosystems, the relationship between biodiversity and gender and the effects of new technological developments on agriculture in the mountains of the Indian Central Himalayas.

Biodiversity forms the fundamental basis of all life and sustainable development. This diversity is not only reflected in the number of species and their varieties, but also in ecosystems and their linkages – often biomass flows – between all these. Among the values which are ascribed to biodiversity are the direct – consumptive and production – values, and the indirect, or non-consumptive, e.g., recreation, option (future), and existence (ethical) values. The life-support value as such as well as the cultural basis of biodiversity is often neglected. It is obvious that the Himalayan mountains harbour the major proportion of biological diversity.

Development of agriculture which had started about 10,000 years ago is based on the domestication of wild herbaceous plants. The value of landraces or folkseeds, which have been cultivated by local peasants for millennia, as local pools of well-adapted biodiversity for local and global food security and ecological stabilization, cannot be overestimated. The base of forest genetic resources, with their multifunctional values, might even be broader, but is less known and decreasing at a fast rate. Wild relatives of crops still contribute considerably to agricultural production and food security.

Several aspects of biodiversity in the agro-ecosystems are central:

a. the co-existence of the forestry, animal husbandry, and cropping and the linkages between these sectors (such as fodder from the forests to the animals, manure from the animals to the agricultural land, grains to the people and fodder to the animals);
b. the diversity of species in each sector; and
c. the variety within each species.

The erosion of biodiversity at the moment is the greatest in recorded history; probably 40,000 times higher than ever before. Almost all ecosystems are threatened by one species: man. This is primarily due to a reductionistic approach, or maldevelopment, in which material profits and economic growth prevailed above other values (such as sustainability and equity), in which natural resources were seen as free goods to be used by man without limitations, and which favoured some, but marginalized many people. Over-exploitation of natural resources and pollution of the environment were the result.

The Green Revolution, which spread in the 1960s all over the world, is based on the introduction of so-called high-yielding 'miracle' seeds, together with a package of agro-chemicals, irrigation, and mechanization. It has resulted in a reduction of species and varieties (replacement of multi-cropping system by monocultures), a breakdown of the agro-ecological cycles between sectors and their biomass flows, a loss of multi-functionality, an increase of pressure on land, an increase in ecological vulnerability of the system for pests and diseases and ecological instability, an increase in environmental pollution, a loss of control by local producers and a decrease in their access to resources (and greater dependence on external actors and inputs as free goods become commodities), and a loss of local knowledge and culture.

The White Revolution, which was based on the replacement of pure indigenous breeds by homogenized hybrids of Zebu cow with exotic strains, was merely focusing on the improvement of dairy production for sale. Almost the same consequences as the Green Revolution can be observed here.

The same can be said for the developments in forestry, which for the last 20 years has mainly been based on the replacement of diverse forests and/ or agricultural and grazing lands by industrial plantations of exotic species, such as Eucalyptus and pine. Only the fast increase in timber yield was the objective of these developments, whereas other forest attributes have been grossly ignored.

Recent developments in biotechnology, both in agricultural and tree crops as well as in domestic animals, will only increase the above-mentioned trends and erode biodiversity even further. In India, there is much support from the government and private sector for research and development ((R & D) in this field. These are primarily focusing on the large-scale production and fast multiplication of so-called elite plants and breeds with high commercial value. Also a greater resistance and wider applicability are among the characteristics which are emphasized. Only certain species of crops and animals are promoted, with defined purpose to breed out indigenous ones. This, as well as the wide-scale application, will result in an increase in uniformity between and across species. The unifunctionality biotechnology is based on, does not take into account the ecological linkages between the different sectors in the agro-ecosystems. Even more than the previous technological developments, biotechnology is in the hands of private sector. This means a concentration of plant and animal breeding activities in biotechnological firms. This privatization is even encouraged in India by government strategies such as the New Seed Import Policy. Local producers will become more and more dependent on the purchase of formerly free goods. Also a number of questions can be raised about the ownership and control over genetic resources and the fact that complex organisms are reduced to their parts and treated as inputs in genetic engineering. The patenting of genes will result in a devaluation of life-forms. The reductionism, fragmentation, and privatization of biotechnology will, therefore, have an even worse effect on biodiversity, the environment – in particular in the agro-ecosystems – and local people than the previous technological developments have had.

Conservation of biodiversity up till now has been mainly focusing on:

a) in situ conservation of wild species of plants and animals in parks and reserves;
b) ex situ conservation of agriculturally and commercially important species in genebanks and in vitro storage of germplasm.

Both these methods also have their disadvantages. Through the first method, local people loose their access to and control over resources, it is often too fragmented (isolation of populations) and the negative external influences, such as pollution, cannot be excluded. The second method is very utilitarian and reductionistic, keeping the species or variety out of its (semi) natural environment with its ecological linkages and evolutionary influences.

Apart from these, there is a trend to monetarise the value of natural resources and to promote conservation by making cost-benefit analysis. However, many values of species and ecosystems cannot be expressed in terms of money.

To our opinion far too less attention has been paid up to now to the in situ conservation of biodiversity in the environment where man (men and women) plays a role and interacts with her/ his environment, such as the agro-ecosystem. Probably this would be the most important way to prevent further erosion of biodiversity by maldevelopment.

Apart from biodiversity – but closely linked to that – also socio-cultural and particularly gender aspects have been central to agriculture. Women play an essential role in maintaining the linkages and biomass flows between the different sectors in the agro-ecosystem, and in maintaining and creating biodiversity. Their perceptions, experience and knowledge of, control over and access to the resources are crucial, whereas the (undisturbed) system also 'gives back' almost every thing to meet the needs of the women and their families. In many of their cultural expressions, such as songs and dances, the relationships of the women with their environment is reflected.

For the women, the introduction of agro-technologies has led to a loss of their control over and access to means of production, a loss of resources, a significant increase in their work burden, and deterioration of their physical health. Also an increased uncertainty, loss of their knowledge, experience and culture, a reduction of their influence and increased dependence, and – finally – a deterioration of their position can be observed.

As an important indicator for the position of women the concept of 'autonomy' has been used. It is our thesis that in a traditional, undisturbed agro-ecosystem, women's autonomy is relatively large and the different tasks in the system are more equally shared among the sexes. In a disturbed environment, e.g., by the introduction of new non-adapted technologies and the market economy, however, women's autonomy decreases. The loss of biodiversity and of their control over resources leads to a growing gender differentiation.

It is expected that biotechnology – in the way it is developing now – not only will reinforce the described trends, but will also extend them and go far deeper. This will further deteriorate women's autonomy and the life-support systems she and her family depend upon.

In the mountain economy, still very clearly women's predominant role is in managing the agro-ecosystems as well as the differences between traditional situations and those in transition can be observed – situations in which the scale of autonomy of the community and of women in particular decreases and hardship (with the decrease of biodiversity and ecological destabilization) increases.

A typical mountain agro-ecosystem still shows features of a sustainable agro-ecosystem in which biomass flows are integrated within the main sectors: forests, crops, livestock, and people. Biodiversity is still of great measure. The predominant Himalayan forests play an essential role in the maintenance of an agro-ecosystem by supplying massive amounts of nutrients to the more fragile cropland/ cultivated land via livestock. An agro-ecosystem in the Himalayan mountains is a true representative of *nature-subsidised solar-powered agro-ecosystems*. Most agriculture is rainfed. Managed by traditional knowledge and farmer-evolved technologies, a mountain agro-ecosystem does not depend on external inputs and also not linked with the market system to dispose off its produce and drain soil nutrients into.

However, in recent years here also the Green Revolution has been introduced and intensified with HYVs, chemical fertilizers and irrigation schemes. Mainly in the valleys, land is being cultivated now with HYVs of rice and wheat, cash crops like soy beans and vegetables. The high altitude areas, once stocked with mixed natural oak forests, are now being stripped to give way to indiscriminate apple cultivation and off-season vegetables. This trend has not only increased the influence of cash economy (inevitably leading to social inequity) and changed people's food habits and gender role, but has also increased pressure on land and resources, inevitably leading to a state of perilous ecological imbalance. Biodiversity is eroding and systems like the irrigation channels falling down. The original biomass flows between the different sectors are breaking, as, for example, the foodgrain crops do not provide enough fodder any more. The crossbreeding programme, which has been promoted here since 1956, has had very little success, but has given a blow to the exceptionally hardy, efficient converters, disease resistant, adaptable, terrain-negotiating, environment-friendly, and multipurpose superb local breeds of cattle.

Most of the agricultural operations in mountain areas are run by women farmers, and therefore, most of the technologies have been designed and developed by women farmers. Women's technologies are founded on the ecological principles. They are site-specific and resource-centred. They are humane and futuristic. They are conservation-oriented and resilience-enhancing. They infuse life and stainability in the whole agroecosystem.

Women technologies are based on a rich repository of traditional knowledge that stored in human brains. The traditional technologies evolved particularly by women have been tested over millennia by trials and errors and are perfectly fool proof. These technologies are site-specific and negotiate with terrain conditions. Therefore a great diversity of the technologies exists in mountain areas, like the environmental diversity and the biological diversity in the area. Some of the specific attributes of the gender-specific technologies operating in traditional setting in the mountains are as follows (Singh 2002):

i) maintenance and promotion of equity and cohesion amongst the people of community;
ii) provision of benefits to the poor villagers and large number of the poorest households;
iii) addressing women's practical needs ;
iv) ensuring low investment and high returns;
v) site-specificity and suitability to mountain agro-ecosystems;
vi) feasibility, social acceptability, and fulfilling people's priorities; and
vii) innovation-inducing.

Traditional mountain technologies are the result of women's innovativeness and are still innovation-inducing. They do not only link the present with the past but also guide us into future development of natural resource conservation-oriented agricultural systems.

In the description of the case study, village Bangali in Rath reflects a situation which is almost traditional and undisturbed by external interventions. In the village Jardhargaon in the Henwal Valley, however, the traditional system was once breaking down and now it has been restored. Reversal from the external input-based unsustainable agro-ecosystem to the internal input-based sustainable agro-ecosystem is not an easy process. The biodiversity is one of the key factors to restore sustainability. Biodiversity once eroded from the system does not remain in the custody of local farmers. In Jardhargaon, people had to start a movement – the *Beej Bachao Andolan* (Save Seed Movement). Farmers have now re-introduced most of the varieties of seeds they had lost in the wake of Green Revolution and restored their traditional practices of farming. This has been possible because traditional seeds/ landraces were still thriving in the remote and poorly accessible areas of the mountains where Green Revolution could not spread its tentacles. *In situ* and on-farm conservation of biodiversity is absolutely necessary to ensure farmers' control over it, its sustainable use, and build up a value-based sustainable agri(culture). Had the situation of biodiversity erosion taken place in the accessible plain areas, recovery of the germplasm that is stored 'safely' in gene banks farmers have no access to or control over, and reversal from the transformed agro-ecosystem to a traditional one would have been almost impossible. Biodiversity holds the key to the farming practices. Fertiliser-responsive and irrigation-requiring vulnerable HYVs are difficult to sustain and provide appreciable yields in a traditional setting. They do not only require a new set of alien technologies, but also change cultural values of farming communities.

Women are the backbone of traditional agriculture in the mountains. They do virtually everything relating to land-based activities. They are the real custodians and managers of biodiversity and mistresses of agro-technology. Rather than compartmentalising the agriculture into mere cropping, or animal husbandry, or horticulture etc., women look at and analyse agriculture as sum total of all land-related activities, all the processes through which soil fertility is maintained, conservation of biodiversity is ensured, balance amongst all components of farming (forests, pastures, cropland, livestock, etc.) is maintained, all organic linkages and processes within the farming system components are ensured, cyclic flows of nutrients are regulated, ecological integrity of farming systems is ascertained, diversity of foods is produced, small-scale rural industries based on biodiversity are run, and agro-ecophilosophy guiding the farming cultures to adopt all measures leading to transcendental changes and sustainability is nurtured. Women folk, through agriculture, maintain sanctity of nature and life.

An augmentation of draught animals power system would help mitigate woman's problems. For instance, improved animal harness, efficient implements and tools, increasing DAP supplies through more use of animals, and the likes would reduce work burden on a woman significantly. However, our conventional animal husbandry policy calls for large-scale crossbreeding of cattle. Crossbred bullocks have proved less efficient for ploughing and other agricultural operations. If the crossbreeding programme assumes success to a significant level, drudgery of woman would further aggravate.

A situation of almost complete genetic erosion can be witnessed in a case study of a village in the Bhagirathi Valley. Such genetic transformation in agricultural systems can also be seen in other villages located in irrigated valleys that are easily accessible. Another situation of almost complete collapse of agro-ecosystem and its diversity can be observed in the villages of Chamba-Mussoorie fruit belt. Transformation of agriculture at higher altitudes with high moisture regime is horticulture-dominated. Technologies used to manage these systems are imported ones. These transformations are market-oriented and gender-insensitive. Women, unlike in traditional agro-ecosystems, are not at the helm of all crucial affairs. Their wisdom is hardly of any use here. Their role is only confined to manual work. They are neither the mistresses of their own fate nor the custodians of the biodiversity they manage. This transformation, undoubtedly, is unsustainable and is bound to collapse in due course of time. But if the local germplasm/ indigenous species/ landraces slip from farmers' hands, restoration of sustainable systems would virtually be impossible.

The Central Himalayan mountains are an excellent area for action programmes based on area perspectives and cultural values as there are still villages which are so remote that the traditional system has not been disturbed yet. Going down from high mountains to lower hills and valleys, the level of external interventions increases, whereas agro-biodiversity decreases and gender dichotomy and unsustainability increase.

Traditional technologies evolved and developed by trial and error over millennia by farmers date back to Vedic Age and many should be regarded as innovative and futuristic rather than mere symptomatic of backwardness and a remnant of the past. These technologies should not lose their edge, for they are not only relevant for our present but are also for future. Many of these technologies or strategies are valuable attributes conducive to sustainability of agriculture.

Farmers in the area, particularly the women farmers, are very reserved about their traditional and sustainable farming practices and are staunch opponents of the imposed HYVs at the cost of their own and external technologies responsible for changing farming practices and badly affecting values and sanctity of life. Mountain farmers in this area want to strengthen their indigenous countervailing power – based on a sustainable livelihood paradigm – to stop mainstream developments and reverse their effects.

New policy framework at international, national and local levels governing the process of rampant privatisation under the much talked about globalisation is a serious flaw especially to the marginal ecosystems and communities consciously managing these ecosystems for their sustainable livelihoods.

Mountain agriculture should not be measured against the total quantities of foodgrains to flow from the agro-ecosystems as is done in case of conventional agriculture. It should rather be valued in terms of the valuable biodiversity in its store, quality of the food products produced, its community-based structure, its prospective contributions to future generations, and in terms of its characteristics indicative of sustainability.

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Annex 1

Glossary of Plant Biodiversity in Central Himalayas

English/ Common Name	Local Name	Botanical Name
Aconite	Atis	*Aconitum heterophillum*
Alder	Utis	*Alnus nepalensis*
Alder birch	Kathboj	*Betula alnoides*
Almond	Badam	*Prunus amygdalus*
Amaranth	Ramdana, Chulai, Marsa	*Amaranthus* spp.
Ammi majus	Ammi majus	*Ammi majus*
Apple	Seb	*Mallus pumila*
Apricot	Khumani	*Prunus armeniaca*
Ash tree	Angu	*Fraxinus micrantha*
Axle wood	Bakli	*Anogeissus latifolia*
Oak	Banj	*Quercus leucotrichophora*
Barley	Jau	*Hordeum vulgare*
Barnyard millet	Jhangora	*Echinochloa frumentacea*
Bauhinia	Kachnar, Guryal	*Bauhinia purpurea*
Bayberry	Kaphal	*Myrica esculenta*
Begonia	Begonia	*Begonia* spp.
Belladonna	Belladonna	*Atropa belladonna*
Ber	Ber	*Zezyphus jujube*
Bhamora	Bhamora	*Benthamedia capitata*
Bhanjir	Bhanjir	*Perilla frutescens*
Bhekal	Bhekal	*Prinsepia utilis*
Black berry	Kala hinsalu	*Rubus niveus*
Black locust	Robinia	*Robinia pseudoacacia*
Black gram	Urd	*Vigna mungo*
Black plum	Jamun	*Syzygium cumini*
Blue pine	Kail	*Pinus wallichiana*
Box wood	Papri	*Buxus semipervirens*
Bramble	Tungla	*Rhus perviflora*
Brown oak	Moru	*Quercus floribunda*
Buchwheat	Oogal, Phphar	*Fagopyrum* spp.
Bhimal	Bhimal	*Grewia optiva*
Banafsa	Banafsa	*Viola serpens*
Brinjal	Baigon	*Solonum melongena*
Caraway	Kali jeeri	*Carum carvi*
Carnation	Carnation	*Dianthus* spp.
Cardamom (large)	Bari elaichi	*Amomum koenigii*
Carrot	Gajar	*Daucus carota*
Cauliflower	Phool gobhi	*Brassica oleracea* var. *botrytis*
Cabbage	Gobhi	*Brassica oleracea* var. *capitata*
Chamlai	Chamlai	*Desmodium tiliaefolium*
Chamomille	Babuna	*Matricaria chamomilla*
Cedar	Deodar	*Cedrus deodara*
Chillies	Mirch	*Capsicum annuum*
Chirata	Chirata	*Swertia chirata*
Chir	Chir, Pine	*Pinus roxburghii*
Chestnut	Meetha pangar	*Castanea sativa*
Cherry	Cherry	*Prunus avium*
Chrysanthemum	Guldawadi	*Chrysanthemum maximum*
Coriander	Dhania	*Coriandrum sativum*
Costus	Kuth	*Saussurea lappa*
Cotton	Kapas	*Gossypium* spp.
Crab apple	Crab apple	*Malus baccata*
Cypress	Surai	*Cupressus torulosa*
Dahlia	Dahlia	*Dahlia* spp.
Dhatura	Dhatura	*Datura stramonium*
Emblic	Aonla	*Emblica officinalis*
Ephedra	Somlata	*Ephedra gerardiana*
Figs	Timla	*Ficus aviculata*
Figs	Beduli	*Ficus Scandens*
Finger millet	Mandua	*Eleusine coracana*
Fir	Raga	*Abies pindrow, A. spectabilis*
Foxglove	Foxglove	*Digitalis lanata, D. purpurea*
Foxtail millet	Kauni	*Setaria italica*
Frenchbean	Frenchbean, Rajma	*Phaseolus vulgaris*
Ghani	Ghani	*Myrsine Africana*
Ginger	Adrakh	*Zingiber officinale*
Gladioli	Gladioli	*Gladiolus* spp.
Gram	Chana	*Cicer arietinum*
Groundnut	Mungphali	*Arachis hypogaea*
Guava	Amrood	*Psidium guajava*

English/ Common Name	Local Name	Botanical Name
Gurial	Gurial	*Bauhinia variegata*
Hill lemon	Galgal	*Citrus limon*
Hill orange	Narangi	*Citrus reticulata*
Hill toon	Tun	*Toona ciliata*
Himalayan silver birch	Bhojpatra	*Betula utilis*
Himalayan hornbeam	Chamkharik	*Carpinus viminea*
Himalayan hazelnut	Hazelnut	*Carya illinoensis*
Himalayan pencil cedar	Jhora	*Juniperus macropoda*
Horsegram	Gahat, Kulthi	*Macrotyloma uniflorum*
Jackfruit	Kathal	*Artocarpus heterophyllus*
Jakhia	Jakhia	*Cleome viscosa*
Jatamansi	Jatamansi	*Nardostachys jatamansi*
Kodo millet	Kodo millet	*Paspalum scrobiculatum*
Kharik	Kharik	*Celtis australis*
Lemon grass	Lemon grass	*Cymbopogon citratus*
Lentil	Masur	Lens culinaris
Linseed	Alsi	*Linum usitatissimum*
Litchi	Litchi	*Litchi chinensis*
Lupin	Lupin	*Lupinus hartwegii*
Maize	Makka	*Zea mays*
Mahamaida	Mahamaida	*Pogonatum multiflorum*
Mango	Aam	*Mangifera indica*
Mandarin	Malta	*Citrus sinensis*
Manipuri oak	Manipuri banj	*Quercus serrata*
Mapple	Kanchula	*Acer caesium*
Marigold	Hazari	*Tagetes erecta*
Mesembryanthemum	Ice plant	Mesembryanthemum *tricolor*
Minrung	Minrung	*Polygala croota*
Mint	Pudina	*Mentha arvensis*
Mint	Peppermint	*Mentha piperita*
Mulberry	Kimu, Toot	*Morus serrata*
Mung	Moong	*Vigna radiata*
Mustard	Rai	*Brassica juncea*
Narcissus	Narcissus	*Narcissus* spp.
Oak (Kharsu)	Kharsu	*Quercus semecarpifolia*
Oat	Jai	*Avena sativa*
Onion	Pyaj	*Allium cepa*
Orange	Narangi	*Citrus aurantium*
Orchis	Salam mishri	*Orchis latifolia*
Pashanbhed	Pattharfod	*Berginia lingulata*
Pattherlong	Pattherlong	*Didymocarpus pedicellata*
Pansy	Pansy	*Viola tricolor*
Pea	Matar	*Pisum sativum*
Peach	Aru	*Prunus persica*
Pear	Nashpati	*Pyrus communis*
Pear millet	Bajra	*Pennisetum typhoides*
Petunia	Petunia	*Petunia hybrida*
Plum	Plum	*Prunus domestica*
Potato	Alu	*Solanum tuberosum*
Potentilla	Bajradanti	*Potentilla fulgens*
Proso-millet	Cheena	*Panicum miliaceum*
Piunli	Piunli	*Rinwardtia trigyna*
Pyrethrum	Pyrethrum	*Chrysanthemum cinerariifolium*
Radish	Muli	*Raphanus sativus*
Rapeseed	Toria, Sarson	*Brasica campestris*
Raspberry	Peela hinsalu	*Rubus ellipticus*
Rhodes	Burans	*Rhododendron arboreum*
Rhodes	Semru	*Rhododendron campanulatum*
Rhodes	Taghisha	*Rhododendron lepidotum*
Rhubarb	Dolu, Arak	*Rheum emodi*
Rice	Dhan	*Oryza sativa*
Rice bean	Naurangi	*Vigna umbillata*
Ring apple	Ring apple	*Acacia alpida*
Rose (wild)	Kunja	*Rosa brunonii*
Sal	Sal	*Shorea robusta*
Salam panja	Salampunja	*Eulophia campestris*
Sandan	Sandan	*Oogenia oogonensis*
Sesame	Til	*Sesamum idicum*
Shullu	Shullu	*Euphorbia royleana*
Shumeo	Shumeo	*Valeriana pysolaefolia*
Siris	Kala siris	*Albizia lebbeck*
Sissoo	Shisham	*Dalbergia sissoo*
Sorghum	Jowar	*Sorghum vulgare*
Soapnut	Ritha	*Sapidus mukorossi*
Soybean	Bhat	*Glycine max*
Spruce	Rain	*Picea smithiana*
Sugarcane	Ganna, Eikh	*Saccharum officinarum*
Sweet pepper	Sagia mirch	*Capsicum frutescens*
Tomato	Tamatar	*Solanum lycopersicum*
Tipatiya	Tipatiya	*Oxalis latifolia*
Tuberose	Tuberose	*Polianthes tuberose*
Vetiver grass	Khus grass	Vetiveria zizanioides
Walnut	Akhrot	*Juglans regia*
Watermelon	Tarbooj	*Citrullus vulgare*
Wheat	gehun	*Triticum aestivum*
Wild hill bamboo	Ringal	*Arundinaria falconeri, A. fulcata, A. spathiflora*

Some are based on GB Pant University (1989)