Three

DAP and Transformation Processes

Agricultural transformation has led to an alteration in the energy system in rural areas. Mechanisation was central to Green Revolution technology. It accords no value to draught animals. Although producers in some highly patronised pockets have widely adopted the new HYVs, irrespective of farm size and tenure, factors such as soil quality, access to irrigation water, and other biophysical-agroclimatic conditions (Conway and Barbier 1988) have been formidable barriers to adoption. The impressive economic contributions of the Green Revolution to large farms in the *Terai* area are to a considerable extent attributable to the massive amounts of fossil fuel energy farm machines use. Farmers in almost all categories in the mountains, who have to be content with HYVs, mono-cropping, and use of very small amounts of chemicals, have to operate all farming activities with human and animal energy.

The following paragraphs will discuss mountain agricultural transformation processes in the special context of DAP. Discussion on current transformed scenarios will be preceded by a description of traditional scenarios and unsustainability indicators and contributing factors. It will be followed by a discussion on limitations households face, changing cropping patterns affecting livestock fodder and the White Revolution technology; all of these have wide-scale implications on DAP.

3.1 The Predominant Situation

In vast areas of the Central Himalayas, a predominant traditional subsistence agriculture is in evidence. The majority of the mountain population is engaged in traditional subsistence agriculture. Inaccessibility or isolation creates favourable conditions for traditional agricultural management. The greater the inaccessibility the greater the chances of traditional management. In isolated areas, farmers tend to be self-sufficient. Natural diversity has been and is used by traditional farmers for sustenance and for developing diverse food production and livelihood systems.

Production activities in traditional areas are less diversified. There are two types of farming system: (i) cereal crop-dominated, and (ii) livestock-dominated. The cereal crop-dominated system is found 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 land in the hills, millet-based on upland mid-altitude lands, and pseudo-cereal-based on high altitude summer camp lands in the middle mountains.

Agriculture in the hills is mostly irrigated agriculture. In the Middle Himalayas it is rainfed for the most part and, in the Greater Himalayas, it is totally rainfed (see Table 2.3). Whereas in the hill zone, both traditional and high-yielding varieties of crops are cultivated simultaneously, in traditional farming areas in the middle mountains crops are usually of traditional varieties. Herds are cattle dominated. DAP, the principal component of the animate energy system, is managed as either independent, shared, hired-in, or hired-out animal labour. Linkages with the market system are poor.

The livestock-dominated farming system of transhumant pastoralists who reside half a year in the Greater Himalayan zone includes herds dominated by ovine species, especially sheep. The average holding is very large and a high frequency of bullock sharing in the energy use system is observed. Alpine meadows are an important component of the farming system, and they are the main source of livestock feed for about six months of the year. Linkages of this system with the external market are also poor. The livestock-based farming system, in fact, is in a primitive stage of development.

3.2 Unsustainability Indicators

Unsustainability indicators relating to the livestock sector in the mountain farming system are listed in Table 3.1. Decreased livestock holdings (number of livestock per family) and a reduction in the proportion of cattle and bullocks in the overall herd composition and draught animals per household; a decrease in area under forests/pastures which serve as sources of livestock fodder and consequent reduction in grazing land due to construction and other activities (especially in the alpine zone); colonisation of exotic plants (*Lantana* sp and *Parthenium* sp) at lower altitudes in the Shivalik and foothill zone; and conversion into cultivated land almost everywhere are among the indicators of unsustainability.

In the context of resource management, increased use of slowly degrading pine needles in animal sheds is observed. These replace leaves of oak and rhododendron which decompose rapidly to enrich manure quality. Promotion of White Revolution technology involving the intensive crossbreeding of local cows with exotic bulls, mainly through artificial insemination which is not conducive to mountain area conditions, should also be regarded as a negative change. In recent years, emphasis by the public sector has been on monocultures of foodgrain crops (such as white-seeded soyabeans) and trees (such as *Eucalyptus*, Poplar, Silver Oak) that do not provide fodder and instead replace fodder-providing crops. Increased use of common property resources (CPRs) for non-pastoral activities and replacement of social sanctions against their use by legal measures are the negative indicators that decrease the options for development of CPRs and, consequently, of livestock resources. A few years ago, a portion of arable land (PPR

Table 3.1: Unsustainability Indicators Related to the Livestock Sector in the Mountain Farming System

Indicators	*Range of Change*	*Indicators*	*Range of Change*
I. LIVESTOCK RESOURCE BASE		III. PRODUCTION FLOWS	
Decreased size of livestock holding	(-) 63-80%	Reduced dung production	(-) 63-80 %
Reduced proportion of cattle in herd	(-) 73-84%	Reduced application of manure to cropland	(-) 60-75 %
Reduced number of draught animals per household	(-)68-84%	Reduced per ha production of crop by-products (straw)	(-) 33-70 %
Increased proportion of crossbred cattle	(-) 0-5%	Decreased level of concentrate feeds	(-) 73-84 %
Reduced proportion of draught animals in the herd	(-) 13-56%	Reduced milk productivity (per head per day)	
Decreased area under forests/pastures	(-) 10-40%	Cows	(-) 33-50 %
Reduced availability of grazing area due to		Buffaloes	(-) 50-67 %
(a) construction works in the high Himalayas	(-) 2-6 %	Higher intensity of plough hiring (no. of families)	(+) 0-40 %
(b) invasion of exotic plants in the lower hills	(-) 20-80 %	Reduced intensity of plough sharing (no. of families)	(-) 30-7 %
(c) conversion into cultivated land	(-) 10-40 %	Decreased availability of suitable wood for tools and implements	Low-High
		Increased time spent in fodder collection from CPRs	(+) 200-400 %
II. RESOURCE MANAGEMENT		Increased dependence on human labour for agricultural work	(+) 100-200 %
Increased use of pine needles as bedding material	(+) 50-100 %	Fodder supplies from	
Use of weeds as bedding material	(+) 0-5 %	Common Land	(-) 50-75 %
Emphasis on White Revolution technology for animal husbandry	Medium-High	Private Land	(+) 100-150 %
Emphasis on non-fodder annuals and trees	Low-Medium	Increased bullock-work hours per day without rest	(+) 67-167 %
Emphasis on HYVs with narrow straw-grain ratios	Medium-High		
Increased use of CPRs for non-pastoral activities	10-60 %		
Replacement of social sanctions of CPR use by legal measures	Medium-High		
Reduced fallow periods for use of PPR as CPR	onths - Few days		

Source : Adapted from Singh(1992). Some of the statistics are based on the present study.

(Time Frame : Approx. 40 Years)

Private Property Resource) was left fallow for about six months a year. During the fallow period that private land used to function as a CPR on which livestock were grazed. Now, due to reduced fallow periods, especially in highly transformed areas, livestock owners have no opportunity to use Private Property Resources (PPRs) as CPRs. Emphasis on high-yielding varieties (HYVs), generally characterised by a narrow straw-grain ratio, in place of native plant varieties with reverse characteristics (i.e., a wider straw-grain ratio) leads to reduction in fodder supplies from cultivated land.

Today, in livestock production flow-patterns, one finds a considerable reduction in dung production, manure application, straw production, concentrate feeds, and milk productivity. A decrease in supplies of wood suitable for agricultural tools and implements is another noticeable negative change. Ecological degradation and reduction in the area of the commons lead to reduction in fodder supplies, while a steep increase in fodder supply from private lands is evident; and these are, obviously, negative indicators. Draught bullocks are overworked throughout the day and receive less care; this is a negative indicator (increase in working days and total work hours with adequate feeding and care would be a positive indicator). A decrease in draught animals also leads to increased dependence on human labour, often resulting in an increase of the burden women farmers bear. Ploughs are hired rather than shared, and this is symptomatic of a breakdown in social cohesion. Negative indicators portraying the dynamism of unsustainability are, of course, not independent. Changes at one level are bound to induce changes at other levels.

3.3 Factors Contributing to a Decline in DAP

Rising population pressure is one of the principal factors causing environmental degradation, in general, and agricultural deterioration in particular. The gravity of the situation can be realised from the statistics on population density in the Central Himalayan region. In 1971, there were 5.22 persons per ha of cultivated land. In 1981 and 1991, this figure was 5.66 and 7.1 persons per ha of cultivated land, respectively. In the present study areas, human density on cultivated land ranges from 8.44 in the hill zone to 14.75 in the high mountains. In the middle mountains, these figures for traditional and transformed areas are 9.87 and 11.62 persons per ha of cultivated land, respectively. In other words, population pressure in our study areas is considerably higher than in the Central Himalayas as a whole.

The average size of per capita cultivated land, an important indicator of the pressure on land, in the Central Himalayas in 1991 was 0.14 ha. Per capita cultivated land figures for our study areas are : 0.22 ha in the hills, 0.13 ha in the middle mountains (traditional), 0.09 ha in the middle mountains (transformed), and 0.10 ha in the high Himalayas. In most of the areas in the Himalayan mountains, according to Partap and Watson (1994), per capita cultivated land declined by 30 to 45 per cent from 1960 to 1980, and this occurred despite the extension of agriculture on to sub-marginal lands/steep slopes.

There is a myth regarding population pressure in mountain areas. It is often stated in official reports that the density of population in mountain areas is much lower than that of the plains. This calculation is made on the basis of the number of persons per square kilometre of geographical area. The fact that population pressure on cultivated land in the mountains is comparatively higher than that in the plains often remains concealed. From the point of view of mountain specificities, this pressure is bound to become intolerably high. Thus, the compulsions for expansion by clearing forests on commons and reserves, and even on steep slopes, have been and are great.

Human population growth generally favours a corresponding growth in livestock population. However, due to a corresponding increase in the number of households, the livestock holding size (number of livestock per household) decreases. This vast population of livestock, in addition to being an important source of family income, nutrition, and agricultural power, also contributes to a general deterioration in the environment, particularly when CPRs have been lost, legal sanctions on the use of CPRs prevail, no community system for CPR management exists, and animals are deprived of cropland produce (mainly the foodgrains as concentrate feed). Common land available per head of livestock in our study areas ranges from 0.02 ha in the Greater Himalayas to 0.34 ha in the Middle Himalayas under traditional farming systems. This stocking rate is too high to allow for the ecological regeneration of the commons. Some pressure on the commons is eased when animals can be provided with fodder from agroforestry systems, reserve forests, and alpine meadows.

An environment has been created for improvements in milk productivity through conventional White Revolution technology. Yet this technology (discussed in detail in a different section of this chapter) has achieved only limited success. The changes in herd composition this has promoted are leading slowly to a decline in multipurpose cattle of native breeds and a steep rise in the population of single-purpose and voraciously-grazing ovines, and this situation will aggravate ecological decline and draught power deficit (Singh 1992).

3.4 The Current Scenario

Commercialisation of mountain agriculture represents the efforts of mountain farmers to use scarce land resources more efficiently for gainful employment and increased incomes. The cropping approach is based on cash crop farming and intersystemic linkages; new forms of diversification (activities); using inputs from science and technology; and building sound upland-lowland linkages (Partap 1995).

Mountain environments provide suitable niches for special activities and products, and harnessing these niches with appropriate location-specific farming activities has comparative advantages in the mountains in relation to the plains. The diverse agro-ecological conditions or farming situations prevailing in the mountains form suitable niches for fruit crop farming, floriculture, spice cultivation, and medicinal and aromatic plants. In the process of transformation, it is fruit crop farming that receives most focus. In the lower fertile valleys equipped with irrigation facilities and well-linked with markets, vegetable-based transformation has taken place. In some areas at high altitudes, particularly between 1,800 and 2,500m, orchards are the core of the process. In selected pockets at high altitudes establishment of apple orchards has brought about a significant change in mountain agriculture. With its high moisture regime, this area also provides an appropriate niche for off-season vegetable farming. Generally, apple cultivation and off-season vegetable cultivation are found together. In lower valleys, changes in the genetic compositions of cereal crops are common.

Generally, transformation in any area is not uniform or total. Several cropping systems, representing both traditional as well as transformed farming, occur concentrated in the same agro-ecological zone, and thus transformation is actually the result of diversified farming activities. This mix of cropping practices tilted towards a commercial farming system, in addition to providing on-farm and off-farm employment opportunities and raising economic standards of the households improves the security of the overall system. One thing is common to the development of the transformed systems mentioned above. They are all energy intensive. In addition to the use of from low to high external inputs, the systems require large amounts of animate energy, as discussed in Chapter 2. In mountain areas, owing to specific circumstances, fossil fuel-powered machines have not become a part of the transformation process as one expects in the plains, for example . Draught animal power and human energy form the only sources of energy initiating and maintaining the transformed system.

3.5 Household Limitations

Different production systems within different agro-ecological zones in the mountains tend to adopt a particular transformation process. The local soil conditions, regional climate, cropping preferences, local productivity, profitability considerations, security aspects, and sustainability are the main factors driving a particular transformation process. The general process, however, is constrained by household limitations. Only those farmers who have profitable amounts of land can afford to meet external input and energy requirements and only these who have sociopolitical awareness can get access to appropriate technology and marketing facilities; these are the farmers who become involved in the transformation process.

Families with marginal landholdings generally do not maintain draught animals. They rather depend on hired bullocks for land preparation. Small landholders generally keep bullocks either throughout the year or only during the land preparation period (ploughing season). Hiring-in and hiring-out draught animals are common practices. Sharing bullocks or ploughs is common, particularly in untransformed areas.

Transformation has reduced the incidence of sharing and has encouraged the incidence of hiring. Families with insufficient labour, as a consequence of male migration or otherwise, generally do not rear bullocks and depend exclusively on hired ploughs.

The incidence of plough hiring persists, particularly among medium-sized groups, if there is a labour shortage. Purchase, sale, and exchange of draught animals among all groups are very frequent.

In recent years, DAP has provided handsome profits and employment for some families, especially in the small and marginal landholding groups. In addition to preparing their own land, these families hire out their bullocks, with or without ploughmen, at prescribed rates. This practice, further strengthened by the transformation process, has emerged as an income-generating enterprise for a number of households.

Unlike in traditional areas, labour exchange and DAP-sharing within a community is rare in transformed areas. And this should be taken as a negative implication on the transformation process.

3.6 Changing Cropping Patterns and Livestock Fodder

Transformation in mountain agriculture is set to have a severe affect on livestock fodder supplies from cultivated land. Presently, an estimated 35 per cent of the livestock fodder supply comes from cultivated land. With continuous pressure on CPRs, dependence on cultivated land for fodder supplies is likely to increase. Yet, the changing trend in cropping patterns involving high-value commercial crops precludes opportunities for increasing dependence on cultivated land for livestock fodder. In the horticulture-dominated farming system, the foremost type of transformed agriculture, land is no longer used to provide fodder for livestock.

The trend of changing cereal cropping pattern is also not conducive to livestock health. The total area under agricultural crops has declined over the past decade, i.e., from 1980-81 to 1990-91. A look at the total production and productivity of foodgrain crops (Govt. of UP 1993) reveals that the decline is particularly evident in the case of cereals. Among the cereals, according to mid-1980s estimates (Singh and Naik 1987b), nearly 56 per cent of the total dry fodder derivable from cropland in the Kumaon Himalayas was contributed by two millet crops, finger millet and barnyard millet. Yet both these crops have registered a maximum decrease in area cultivated over the last decade. Pulses, the second source of good fodder from cultivable crops, have also declined in terms of area sown. Soyabeans are the only pulse/oilseed crop to maintain an increasing trend in area under cultivation as well as in production. But giving this 'introduced' crop, so much emphasis does not provide fodder, and it usually replaces the millets, which are also the principal fodder crops. Barley, the only cereal that provides dry fodder as well as concentrate has also registered a considerable decline both in area under cultivation and production.

Increase in the productivity of important crops has been possible thanks to the adoption of HYVs and external agro-inputs. Since dwarf HYVs are characterised by narrow straw-grain ratios, their adoption in favourable areas has not led to an increase in fodder supplies. Moreover, the fodder provided by HYVs is less preferred than that provided by the long-stalked native crop varieties. Mountain farmers give great importance to the high fodder-yielding native varieties of crops. Poor straw yields inherently associated with the dwarf, high grain- yielding varieties have been among the factors that have had an adverse impact on the agricultural transformation process, particularly in the large-scale adoption of new varieties of food crops.

3.7 White Revolution Technology - Implications on DAP

Crossbreeding of indigenous cattle with European bulls has, for decades, been the standard institutional approach for improving the production and productivity of cattle in the Himalayan mountains, as also in the whole country and, in fact, all over the Third World. In the Central Himalayan region, crossbreeding programmes initially began in 1956 at Vikas Nagar, Dehradun district in Garhwal where Jersey bulls imported from Europe were introduced. This activity was extended to Ranikhet in Almora district in Kumaon region in 1963. In 1969, the crossbreeding programme was taken up on a massive scale by the Indo-German Project (IGADA) in Almora (Agricultural Finance Corp. Ltd. 1987).

Cattle improvement through crossbreeding, popularised as the White Revolution, despite massive financial investments, has met with little success. In 1982 there were 94,240 crossbred cattle accounting for about five per cent out of a total of 1,909,929 cattle. In 1988, the crossbred cattle (81198) accounted for about four per cent of the total cattle (1,941,962) in the region. Out of the total bullock population cross-bred bullocks accounted for about five per cent in 1982 and about four per cent in 1988 (Table 3.2).

Table 3.2: Native and Crossbred Cattle in the Central Himalayas, India

Cattle	1982	1988
Total Cattle	**1,909,929**	**1,941,962**
Native Cattle	1,815,689 (95.07)	1,860,764 (95.82)
Crossbred Cattle	94,240 (4.93)	81,198 (4.18)
Total Bullocks	**71,0787** (37.22)	**756,593** (38.96)
Native Bullocks	672,868 (35.23/94.67)	729,244 (37.55/96.39)
Crossbred Bullocks	37,919 (1.99/5.33)	27,349 (1.41/3.61)

Source : Based on the data given in the statistical books for all districts. Figures in parentheses denote percentage of total cattle/percentage of total bullocks.

There have been no official figures on crossbred cattle since then. In the present study, no exotic breed phenotype nor its productive capacity was in evidence anywhere.

While the crossbreeding programme has been considerably successful in the Himalayan *Terai*, in the hills and mountains it has been largely discarded. 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 supplies of feed such as cultivated leguminous fodder and concentrates – the cakes and foodgrains. If limited cultivated land is spared for livestock production (for raising leguminous fodder) and if a large proportion of the foodgrain goes to the animals (to meet their need for concentrates), then animals would be in direct competition with human beings.

- Leguminous fodder crops grow well on irrigated land. In the mountains of the Central Himalayas only about 10 per cent of the arable land is irrigated. If a sizable area of this land is put under fodder cultivation, it might further aggravate the problem of family food supplies in an area that is already food-deficit and imports large quantities of foodgrains from the plains. In a subsistence farming situation, setting aside fertile land for purposes other than food production is very risky.

- Native cattle can eat considerably more poor quality roughages than exotic cattle breeds because the gut contents of local cattle account for 33 per cent of the body weight, far more than in the case of exotic cattle in which the gut contents account for only 20 per cent of the body weight (Orskov 1984). Indigenous breeds convert the roughages, supplemented with green fodder (grasses and leaves), more efficiently than their crossbred counterparts (Nair 1982 and Jackson 1985). Native cattle can sustain and produce to some extent, by feeding on poor quality roughages of crop residues on which exotic cattle cannot even survive.

- Crossbreds are more prone to diseases, external parasite attacks, and weather extremes, and mountain farmers prefer to keep breeds that are hardy and adapted to local environment and feed resources. Exotic breeds cannot cover long distances; negotiate with rugged, narrow, and stony paths; or graze on steep mountain slopes, but local cattle can.

- Crossbreeding as such is very expensive technology for livestock development. This not only compells livestock owners to depend on the market system for essential feed items—cakes, brans, mineral mixture, vitamins, additives, etc — but also requires a whole veterinary network to take care of the health aspects and manage breeding programmes. Indigenous livestock, on the other hand, consume the feeds produced within the system.

- Local cattle consume biomass from forests and grazing lands and transfer its nutrients to cultivated land, eat crop residues, and recycle the nutrients to the same land on which they grow. The linkages of local cattle with other farming system components are stronger than those of exotic or crossbreds whose linkages, especially with common property resources, are either non-existent or very weak.

- The crossbreeding policy does not take into account the environment in which the animals have to live and produce (Singh 1994). In developing or less industrialised countries, the environment cannot usually be controlled. As animals have many functions, diversity has survival value. Moreover, animals selected on the basis of homogeneity do not fare well, as is illustrated by the many failures following importation of 'upgraded animals' from industrialised countries to less industrialised countries (Orskov 1995).

- The energy efficiency of crossbred dairy cows under specific mountain conditions is very low (Singh and Sharma 1993).

Female crosses of European (*Bos taurus*) and zebu (*Bos indicus*) breeds of cattle, however, have been well accepted by farmers in warm climates thanks to their increased lactation length, higher milk production and earlier age of calving. Crossbred females have also been fairly well received even in the Himalayan *Terai* owing to their production traits. White Revolution technology was successful, significantly, only in areas where large chunks of fertile land could be devoted to animal feeding, where good veterinary services could be provided, and where there was mechanisation. Nevertheless, it was successful at family level, not at community level. In the community-based setting of the mountains, only programmes that are acceptable at the community level are likely to be successful, not those accepted by individual families.

Crossbreeding, in essence, aims to create highly specialised animals. Dairy farmers in industrialised countries keep cows that provide a lot of milk, beef farmers keep specialised beef animals. The market-oriented approach in these countries has led to homogeneity of both crops and animals in a new, controlled environment (Orskov 1995). This may not be the case in poor regions. Neither the farmers themselves nor their crops or animals in such regions are specialised. Diversity in the whole system and diversity in every component of the system provide the key to a sustainable standard of living. This is especially true of farmers in marginalised mountain areas.

Draught breeds kept by mountain farmers are multipurpose ones. They provide manure and power for agriculture and milk for the household. Pouring exotic genes into local cattle, if it is successful, will lead to the extinction of draught power.

There has been little acceptance of crossbred males for draught purposes in the plains because of the general opinion that their working performance is inferior to that of indigenous cattle, since they do not have the large distinctive hump and are unable to tolerate high temperatures (Goe 1983; Singh and Naik 1987a). Farmers all over India have been reported to consider crossbred bullocks inferior in stamina, strength, and vigour to local bullocks (Mali et al. 1983). Scientists who have worked on the draught efficacy drive for crossbred bullocks have concluded that crossbred females are good milkers if fed adequately, but when examining the field performance of their male counterparts, it is found to be extremely low, and these animals are not suitable as work animals (Annaji Rao 1983).

Roy et al. (1972) and Anand and Sundaresan (1974) have argued in favour of crossbred bullocks on the basis of these animals' heavier body weights and better field performances between 06.00 and 08.00 hours; but they have admitted that working crossbreds after 10.00 hours is difficult.

Rajpurohit (1979), after examining the performance of crossbred bullocks as draught animals critically, stated that the physical efficiency of bullocks should not be confused with economic efficiency. According to him, a crossbred bullock requires at least 50 per cent more feed than an indigenous breed of bullock; its economic efficiency, therefore, for the same unit of work, turns out to be only two-thirds that of the latter.

It should be emphasised, however, that energy output depends on many other factors; timely operations, timely avialbility of inputs, weather conditons, and so on; and not merely on the type of breed. Despite the fact that local animal breeds have very useful attributes compatible with mountain specificities and, therefore, need to be preserved, the crossbreeding programme might be useful in the *Terai* and foothill areas where fodder is plentiful and crossbreds are often used for cart haulage.