Ten
Summary and Conclusions

Draught animal power (DAP) is an outstanding example of mass-level application of perspective-based technology by mountain farmers, and it promises to play an important role in sustainable development of mountain agriculture.

Focussing on the three main agro-ecological zones, namely, the Shivaliks/foothills, the middle Himalayas (both traditional and transformed areas) and the Greater Himalayas (high mountains) in the Central Himalayan region of India, the study presents the current state of DAP in mountain farming systems, arguing for the vital role draught animals and the DAP system play in the context of sustainable development of mountain agriculture.

In addition to their vital services in terms of agricultural operations, the draught animals' role in providing income and employment to households is unique . Their social, cultural, and ecological contributions help promote the sustainability of the farming system. Draught animals, in fact , are the most important animal species in mountain agriculture.

The emerging commercialisation of agriculture through cash crop farming, in some favourable areas, demands more intensive use of energy, including DAP. Though this kind of development is to affect the DAP to a certain extent by way of reduced fodder supplies from the farms, its net effect in the Middle Himalayas, where most of the fodder requirements are met from CPRs, would be DAP - promoting. In the Shivalik hills commercialisation would be in favour of mechanisation.

The number of cattle per household is the largest in the Middle Himalayan zone under the traditional agricultural system and the smallest in the villages under transformed agriculture in the same zone. The cattle size and sex-ratios are the major determinants of DAP managemental adjustments in the mountain farming system. A size of less then two bullocks per household points to some degree of hiring and/or sharing. Degree of inaccessibility or isolation, both in terms of distance from the main road in the region and from the plains, and traditionalism influence the size and density of draught animals. Outmigration or working away of adult males discourages large bullock holding sizes and density and also affects overall DAP management as also does the limited substitution of DAP by tractors in the Shivalik hills. The total effect, of course, depends on the relative strengths of all factors.

While the DAP hiring-out practice is completely absent in the Greater Himalayan zone, it prevails in all other agro-ecological zones. Large landholders, except in the traditional middle mountain villages, do not hire-out bullocks. In the event that all households cannot afford to own a pair of bullocks, sharing DAP is clearly a positive indicator, for it tends to keep the population of draught animals in balance, promotes efficient and economic use of the existing population, and also stimulates social cohesion. While hiring in DAP saves expenditure on bullock rearing throughout the year, hiring out, which has been strengthened through the commercialisation of agriculture, has created avenues of employment and income generation for some small and marginal families.

The most draught power is needed for ploughing. Tractive effort by bullocks, in terms of body weight, ranges from nine per cent during weeding-earthing-up operations to 19 per cent during puddling operations at speeds of 2.6 to 1.6 km per hour. Tractive effort during ploughing is about 16 per cent of bullocks at a speed of 2.4km per hour. These high values are indicative of the special ability of the light weight and hardy, native draught animals to generate a greater percentage of body weight as tractive effort. A pair of bullocks, on an average, tills and levels 1,100 sq. km. per day after seven hours of continuous work. Per animal (average weight 250 kg) draught power output during ploughing is 0.26 kWh (0.35 hph).

Apart from in the Middle Himalayan area under traditional agriculture, all the agro-ecological areas face a shortage of DAP in terms of the available annual DAP potential. While agriculture in the transformed and high altitude areas faces only a marginal DAP deficit, in the hill areas the available DAP is much less than required. But nowhere in the hills and mountains have farmers faced a power crisis during peak periods. This is due to the DAP management system in the mountains. In the hills, some power requirements are met by tractors. A pair of bullocks can cover an area of 1.5 ha effectively. While in the Greater Himalayas the cropland area per bullock pair is more or less the same, in the traditional middle mountains, the cropland area is much less than a pair of bullocks can cover. Farmers in transformed mountain and hill agricultural areas own much larger cropland areas than a pair of bullocks can cover. The current DAP management practices cope well with this situation.

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. Transformed middle mountain agriculture requires maximum bullock and human hours and energy (11,696 hours and 1,586 kWh) per ha per year, followed by hill agriculture (10,807 hours and 1,419 kWh). While traditional middle mountain agriculture uses more energy (592 kWh) than high mountain agriculture (533 kWh), the former requires less work hours (3,917) than the latter (4,685). Bullocks work for only 59 days a year in the high mountains, but in the transformed middle mountains they are used for as many as 236 days a year. Agricultural transformation is an energy-intensive process. Of the total animate energy, high mountain agriculture uses only 41 per cent DAP, hill agriculture about 52 per cent, transformed agriculture about 54 per cent, and traditional agriculture as much as 62 per cent DAP for crop cultivation. Cropping intensity increases pressure on human beings for energy use. High mountain agriculture is the exception, for many households in a typical livestock-based farming setting use only hand tools, and kidney bean and potato cultivation need a lot of human energy. The transformed agricultural system makes the most efficient use of available DAP and human resources, and this is reflected in the higher degree of cropping diversification and higher crop yields in the area.

The energy efficiency of the traditional agro-ecosystem is considerably higher than that of other agro-ecosystems. This is due to a very low energy input compared to energy output. Energy output - input ratios of crop production in the hills, transformed, and high Himalayan agro-ecosystems are 2.98, 3.81, and 2.51 times lower, respectively, than in the traditional agro-ecosystem. High energy input compared to energy output in the hills and transformed mountains and overall low energy output in the high Himalayas are attributable to the relatively lower energy efficiency of agriculture in these agro-ecosystems. The amaranth-kidneybean cropping pattern in the traditional middle mountains has the highest energy efficiency. Crops that do not employ imported energy (chemical fertilizers and pesticides), such as upland rice, maize, upland wheat, finger millet, barnyard millet, kidney beans, and naked barely, also demonstrate quite high energy efficiency.

Institutional policies and programmes relating to the animal husbandry sector and having a focus on crossbreeding of indigenous cattle with exotic bulls have serious negative repercussions on the DAP system in the mountains. Crossbred bullocks have poor compatibility with the local environment, feed resources, and harness system. Farmers' strategies in the DAP usage system that involve native cattle breeds adapted to and suitable for local conditions must be appreciated.

What will be the future of DAP? Despite a decrease in operational holding sizes, the commercialisation of agriculture involving short-duration cash crops will increase. Commercial crops need more energy inputs. There will be increased use of external energy inputs, but there will be no alternative to DAP as a source of motive power. The draught animal population might decrease but a new DAP management system will emerge. Perhaps the cow population will be concentrated in a few pockets, for example, in the foothills or adjoining plains, for the purpose of bullock reproduction. Trade in bullocks between the mountains and the plains will increase. Farmers of medium and large holdings become accustomed to maintaining bullocks only during ploughing season and a majority of them will resort to hiring. Many farms will experience shortages of DAP during 'turn around time' (the number of days between harvesting the first crop and starting to prepare land for the next crop). The sharing practice will vanish perhaps. While some farmers of marginal and small holdings will switch to manual operations using no DAP, a majority of them will benefit from the hiring out of DAP to large farms and the trade in bullocks.

Since the nature and intensity of problems related to DAP are different for different farming systems/ ecological areas, the policy measures to overcome these specific problems will also have to be different. Even the transformed areas within the Middle Himalayas vary greatly in terms of demand and supply of DAP, accessibility, adoption of new technology, etc, and this has important implications for mechanisation, animal breeding strategies, feed and fodder supplies, and so on.

In some areas of the Shivalik hills, selective mechanisation (e.g., use of tractors for land preparation, threshing, etc) may be a desirable strategy because of higher cropping intensity, short turn-around time, accessibility, favourable terrain, and a high DAP-deficit.

DAP deficit may become a critical constraint to increased production in those areas of the transformed Middle Himalayas that specialise in the production of vegetables and improved varieties of cereal crops. The number of bullocks is declining over time in these areas, due to factors such as decreased fodder production on the farm and human labour shortages (because of the energy-intensive nature of the crops grown in these areas). Action needs to be taken so that DAP deficit does not become a binding constraint to increased production. Possible options include credit support to small and marginal farmers to raise bullocks in adjoining non-transformed villages, so that they can provide bullock rental services to farmers in transformed villages; development of technology to increase the use efficiency of available feed and fodder resources; selective mechanisation to reduce drudgery and cover peaks of human labour use, and so on.

An appropriate, perspective-based cattle breeding policy, especially aimed at conserving the uniquely adapted draught qualities of the native breeds, may well be valuable for sustained production in the long term. Policy recommendations should not be generalised to all agro-ecological regions. In some areas, where fodder availability can support the animals and where DAP deficit is not a problem due to less intensive crop production possibilities, crossbreeding might be desirable.

The promotion of crossbreeding is not a desirable strategy for areas in which crop production is the main enterprise but where DAP deficit is constraining crop production, e.g., the traditional areas of the Middle Himalayas.

The supply of DAP depends on the number of draught animals, their quality (size, health, breed, adaptability, etc), and the efficiency of the mechanism for transforming this power into useful work. An improvement in the DAP system would be instrumental in augmenting the sustainability of mountain agriculture. Better feeding and better designing of ploughs, yokes, and harnesses are the key elements to realising the full potential of the draught animals available. Adequate infrastructural facilities in terms of R&D to promote and augment the DAP system are vital for sustainable development of mountain agriculture.