Chapter 7
Water Resources

Water sustains life. Its efficient and cost-effective management is critical for meeting the growing demands of population, navigation, irrigation, energy generation, recreation, fishing, urbanisation, and industrialisation. The Himalayas, which are characterised by a great diversity of micro-meteorological conditions, need careful study of geographic, climatic, hydrological, and ecological aspects in different drainage basins and sub-basins, at different locations, and altitudes and in the cascades of nesting micro-, meso-, and macro-watersheds in order to ensure balanced and optimal use of water. Local, regional, and international factors come into play while considering the development and management of the Himalayan river systems in a manner that would meet the competing, multiple needs and demands of different stakeholders in a fair and equitable manner, and at the same time ensure the environmental integrity of this important resource in a sustainable way.

National Water Policy 1987

The National Water Policy document was published in 1987. It underlines the importance of water for human and animal life. It understands that water is critical for maintaining the ecological balance and essential for economic activities and development. The increasing scarcity of water is recognised. Water is to be treated holistically as a part of the larger ecological system. It is important to develop, conserve, and utilise it efficiently and economically.

Stress has been laid on evolving a well-developed information system (databanks, networking, and info-exchange). The strategy advocates maximising retention and minimising losses. Water planning is to be basin or sub-basin based. Recycling and reuse are emp hasised. It is suggested that water projects should provide for drinking water first and, then, irrigation, flood mitigation, hydropower generation, pisciculture, recreation, and industrial and other purposes. During implementation of such projects the 'preservation of the quality of environment and ecological balance should be a primary consideration'.

An integrated approach should be used to address issues of catchment treatment, rehabilitation of the affected people, and command-area development. The document further states:

'The planning of projects in hilly areas should take into account the need to provide assured drinking water, possibilities of hydropower development, and proper approaches to irrigation in such areas in the context of physical features and constraints such as steep slopes, rapid runoff, and incidence of soil erosion'.

It spells out that there should be 'close integration of water-use and land-use policies' and, that:

'water rates should be such as to convey the scarcity value of the resource to the users and foster motivation for economy in water use'.

Every effort should be made to involve farmers in water management at the field level. Waterzoning should guide economic activities. Conservation must be promoted through education, regulation, incentives, and disincentives. For mitigating severe flood impacts, soil conservation, catchment area treatment, increased afforestation, and building of checkdams have been suggested. Training and use of the latest technologies are listed as important needs for scientific water development and utilisation. The document has not attempted a benchmark evaluation nor has it laid down any quantitative targets for the future.

Water (except for interstate rivers, river valleys, and national waterways) is a state subject under the constitutional division of powers and, therefore, most action in its management is taken at the state level and below. Many of the prescriptions listed in the national policy remain unimplemented. Interstate water disputes exist in the absence of effective mechanisms to resolve them. Water rates have not been rationalised, giving rise to a heavy and mounting burden of subsidising irrigation, on the one hand, and promoting waste, on the other. A volumetric approach to pricing water for irrigation is missing. Water conveyance losses are heavy. Drainage problems continue. Appropriate policies for re habilitation of displaced persons in large multipurpose projects are required to overcome public resistance to such projects. Some progress has been made in enlisting community participation in the distribution of water. In mountain areas, traditionally, communities have performed this role. Water- harvesting in hill regions is yet to become a wide-based programme. Similarly, drip and sprinkler irrigation in water-scarce areas has yet to make headway, particularly in the NWHRI.

Water Resources in the NWHRI

Land in the hills cannot be considered as a resource in isolation from water. Rivers represent vital drainage paths in the NWHRI. The region is drained by many river systems, the most important being the Indus, the Yamuna, the Ganges, and the Kosi. The Indus has a catchment area of 468,068 sq.km. up to the Indo-Pakistan border. Consequent upon its flow in steep-sided deep valleys, its erosive activity is extremely high, and it carries about one million tonnes of suspended matter each day (Spate and Learmouth 1984). All the major rivers flowing in Jammu and Kashmir are tributaries of the Indus—two important ones being the Jehlum and the Chenab. The average annual flow of water is 207.8 billion cubic metres for the Jehlum, and 29 billion cubic metres for the Chenab. Some rivers of Himachal Pradesh also finally join the Indus: the Beas and Sutlej, that pass through Himachal Pradesh before flowing down the plains of the Punjab, finally flow into the Indus. The Yamuna originates at Yamunotri glacier in the Uttar Pradesh hills, flows into Himachal Pradesh, debauches from the hills near Tajewala, and then follows a longish passage touching Delhi, Mathura, and Agra before finally confluencing with the Ganges at Triveni, Alla habad. Its catchment area in the hills is 2,320 sq.km.; its main tributaries are the Tons, Giri, and Bata. In the NWHRI, the Ganges mainly drains the Garhwal Division of the Uttar Pradesh hills. Its two main tributaries, the Alaknanda and B hagirathi, rise from opposite sides of Chauk hamba peak and meet at Dev Prayag to form the Ganges. The Ganges has many other tributaries such as the Pindar, Mandakini, and Nandakini. The Kosi system is small and drains the eastern part of Kumaon Division. It is not snow-fed and, therefore, its flow fluctuations from month to month are severe. In addition to the river systems, the NWHRI is endowed with many glaciers (Gangotri, Milam, Pindari, Siachin, etc) and lakes (Hemkund, Rupkund, Vasuki, Kedarnath, Satopanth, Wullar, Dal, Mansar, Surinsar, Pagong, and the Kumaon lakes). The region also has a large number of perennial springs and, in some areas, artesian wells. Table 15 gives information about the potential and usable water resources for important basins and sub-basins in the NWHRI and India.

Since total availability normally oscillates in a narrow range, there is a limit to the potential that can be realised. Water flows in mountain areas have characteristics of sharp seasonality and rapid flows. Availability remains limited. Thus, irrigation is limited and, even for fulfilling other water needs, costs are high. The NWHRI, in theory, has sufficient fresh water but there are problems such as unequal distribution, pollution, erosion, and land degradation. Water, in the past, was freely and plentifully available as needs were much lower than they are now. By tradition, water has been an open access resource. It was used and misused with little concern for its intrinsic cost or for its contribution to value-addition. As it becomes increasingly scarce, it goes mainly to those who have political power and economic capital to appropriate it by controlling its source. Unfortunately, water is also grossly under-priced and this tends to encourage misuse and waste. It needs to be priced reasonably so that it becomes accessible but not wastefully so. It also needs to be placed under the control of local communities.

Table 15: Potential and Usable Water Resources in the NWHRI and India

	Indus Basin	Ganges Sub-basin	All-India Total
Water resources potential (cubic km)	73.5	525.0	1869.3
Utilisable surface water (cubic km)	46.0	250.0	690.0
Groundwater (cubic km)	25.5	171.7	452.2
Per capita water (m^3)	1757	1473	2214

Source: Central Water Commission of India 1993.

Management Issues and Strategies

In the NWHRI, incremental additions to irrigation are possible through the setting up of environmentally safe water storage, water- harvesting, extension of gravity-flow systems, use of hydrams, and pump irrigation (expensive). Another approach would be water conservation, although there are water-related environmental issues. It is true that not much can be done about geomorphological factors such as rugged terrain, steep slopes, etc. However, to a limited extent, terrain can be managed by measures such as terracing or impounding of water. Infiltration can be encouraged. Water runoff can be reduced by creating biotic as well as engineering impediments to the free flow of water. Other steps are also possible such as increasing biomass cover, adopting agronomic and silvicultural practices and cropping patterns that are less water intensive, reducing water conveyance losses, setting up simple water- harvesting structures (e.g., polythene-lined shallow tanks), use of hydrams, and adoption of drip/sprinkler irrigation systems where possible.

Water has many competitive uses in mountain areas. It is required for drinking, domestic use, animals, agriculture, forestry, horticulture, all other biomass growth, energy production, and industrial and other purposes. Therefore, policy for its management and use has to be carefully worked out and balanced. A protective and regenerative approach is necessary. Pricing must address both accessibility and the need to conserve water and eliminate waste. Any successful planning of water use should ensure optimal percolation and subsurface flow with a view to achieving recharging of groundwater and regeneration of water springs and water points to improve year-round availability. When water resources are harnessed, the hydrological cycle is manipulated through various structures and means to divert water, distribute it, clean it, and, then, to carry it away for its return to the natural system. These steps can be problematic in the mountains. These areas often have en hanced precepitation, greater incidence of clouds, high runoff efficiency (which can be both an advantage and a disadvantage), and high production of sediment. This hydrological heterogeneity attracts people but it is also the source of a great number of hazards such as erosion, flooding, loss of life and property, and land loss.

Of late, mountain areas in the NWHRI have been subjected to intensive pressures from human activities: rise in human and animal populations, expanding agricultural activities, establishment of transportation corridors, mining of minerals and gravel, construction of storage, multipurpose projects and artificial channels, heavy tourist/pilgrim traffic, increasing urbanis-ation, and deforestation and overgrazing. Most of these pressures act on the hydrological cycle to change both the quality and quantity of water yields in adverse ways. A strategy is needed to ensure the health of water regimes and this demands an integrated watershed management approach. The core strategy has to be a combination of protection, regeneration, and production. In hill areas, a watershed is a natural physio-geographic unit that can also be an effective unit of integrated planning. The geography of mountains is such, that, if the integrity of a watershed is lost or neglected, there is a strong possibility of advantages of development being cancelled out if programmes do not have a 'spatial fit' with the catchment. Most mountain areas are rainfed and integrated area development should focus on balanced and sustained use of resources in a growth mode. It should include production from individual holdings, regeneration of common-property land resources, and promotion of household production systems.

People's Participation

The adoption of an integrated watershed management strategy often means changes in the use of land, water, trees, animals, technology, skills, and economic relations. Hill societies are usually traditional in outlook. Hill farmers generally try to produce their own needs. Change may mean moving away from this 'wholeness'. Also, the cycle of subsistence may be disrupted if new (more profitable) land use causes returns to flow in a longer time-frame. Scientific land use involves rotational closures of forests or grazing lands which is often not acceptable to local people. Change may be viewed, especially by the rural poor, as an attempt to deprive people of current access to resources in the hope of better returns in some distant, uncertain future. These are problems that can be resolved only by education, persuasion through informed discourse, social mobilisation, and compensation where change may involve temporary loss of income or curtailment of resource use. The need, therefore, is to stimulate collective initiatives and action in institutional contexts so that communities are organized, motivated, and facilitated for planned action. In this endeavour, village *panchayat*(s), *van panchayat*(s), women's groups, youth groups, and similar collectives have a role to play. NGOs can play facilitating, communication-bridging, and model-building roles.

Irrigation

Irrigation in the three subregions of the NWHRI is limited. In Jammu and Kashmir, the net area sown was 732,800 ha in 1996-97, while the net irrigated area was 313,260 ha (42.7%). Sources of irrigation were canals (84,250 ha), tanks (2,570 ha), wells (1,420 ha), and other sources (25,020 ha). The gross irrigated area was 447,000 ha — which means that the area irrigated more than once was 134,000 ha (Jammu and Kashmir Directorate of Economics and Statistics 1996-97). Groundwater potential in 1984 was estimated by the Central Water Commission at 3.7 km^3/yr while the draft was only 0.050 km^3/yr (1.35%). In Himachal Pradesh, net sown area was 572,000 ha in 1994-95 while net irrigated area was about 100,000 ha (17.5%). The sources of irrigation were canals (6,473 ha), wells/tube-wells (11,100 ha), and other sources (81,937 ha). The gross irrigated area was 171,000 ha, indicating that the area irrigated more than once was about 71,000 ha. According to the Central Water Commission (1985) the irrigation potential was 385,000 ha but less than half had been used by 1994-95. Groundwater potential was estimated at 0.29 km^3/yr but only one-fourth had been utilised up to 1991-92. In the Uttar Pradesh hills, net sown area was 666,665 ha in 1993-94 while net irrigated area was 231,673 ha (34.8%). Figures for source-wise irrigated area are not available; the irrigation system was comprised of 5,822 km of canals, 387 state tube-wells, and 6,298 private tube-wells. Gross irrigated area was 389,613 ha, indicating that an area of 157,940 ha was irrigated more than once.

Drinking Water

In Jammu and Kashmir, 99.69 per cent of the total number of 6,477 villages had a piped-water supply by 1996-97. In Himachal Pradesh, 87 per cent of the total number of 16,807 villages were covered by a drinking water programme by 1994. In the Uttar Pradesh hills, 99.5 per cent of the total number of 15,806 were covered by drinking water programmes by early 1996. The drinking water figures in terms of the percentages of villages covered may look bright but, on the ground, the situation is different. Many drinking water schemes are non-functional; in many others, water yields have fallen sharply while some water sources have dried up altogether.

National Watershed Development Programme for Rainfed Areas

The National Watershed Development Programme for Rainfed Areas (NWDPRA) was launched in 1990-91. It covered 10,000 villages with an area of 3.7 million ha (15 million people) and also included mountain uplands. It was based on a farming systems' approach. Detailed guidelines covered surveys, project preparation, laying of nurseries, demonstration management of common property land resources, livestock development, people's participation, and involvement of NGOs. In-built provisions existed for research, monitoring, and review. Emp hasis was placed on making use of every resource available and on building on local knowledge. The main planks were affordability, replicability, and sustainability. A World Bank project was launched in the Uttar Pradesh hills in the 1980s, but it had limited success. It did not mesh with ongoing development programmes in the area. A second World Bank project for hill areas was initiated in 1990-91. Three projects were started with assistance from the European Commission in the degraded ecosystems of the Uttar Pradesh hills. Implementation was better on account of the adoption of participatory rural appraisal techniques. Most programmes are donor driven and patterns of implementation vary in nuances and emp hasis. The NWDPRA relies largely upon water conservation technologies where greater use of biological means is attempted to control erosion, use of organic manure is promoted to improve *in situ* moisture, and efforts are made to integrate diversified production systems, e.g., mixed farming, agroforestry, water-harvesting, dryland horticulture, and livestock development. Self-help groups are established. Of net income, 10 per cent is transferred to the village development fund and 15 per cent to a revolving fund used for common property land resource development. The remaining 75 per cent is shared by the beneficiary group. The results of the NWDPRA are mixed, but it is a beginning that needs to be pursued and built upon with purpose and determination.

Case Study of Nahar Village, Dehradun District

Nahar is one of the 13 villages of Sectla Rao subwatershed in Sa haspur block of Dehradun District. The total area of the village is 72 ha of which 20 ha are reserve forests, 39 ha are agricultural lands, and the rest either uncultivable fallow or other miscellaneous types of land. About 56 per cent of the agricultural land is irrigated. The village is comprised of 45 households with a total population of 249. Nearly two-thirds of the population is literate. Most of the land holdings are small and scattered. The animal population was about 235 before the village was brought under the watershed management project supported by the European Commission. At the beginning of the project in 1995-96, villagers met about four-fifths of their fuel requirements from adjoining reserve forests while the rest came from agricultural lands and other alternative sources. There was an annual fodder shortage of about 240 tonnes.

The strategy of the project was additional plantations, introduction of high-yielding varieties of agricultural crops, improvement of biomass production, and promotion of alternative sources of energy such as biogas. It also included reducing the number of animals with low productivity and replacing them with high-yielding, stall-fed buffaloes. Training was an important component and village planning was attempted essentially through participatory rural appraisal. Villagers voluntarily agreed to reduce the number of goats.

Once the consensus of villagers had evolved through participatory rural appraisal, the project selected entry-point strategies in the form of financing biogas plants, providing mini-kits and better implements for agriculture, and repairing terraces. Also, the irrigation system was improved. Eight water-harvesting tanks were built. For the animal husbandry programme, a high-quality breeding facility was provided, fodder mini-kits were distributed, and chaff cutters and feed troughs were introduced. In the adjoining reserve forest, plantations were undertaken with the involvement of villagers. On more than 10 ha of land, silvi-pastoral development was carried out. On about two ha of land, private orchards were established. Vegetable mini-kits were distributed.

While inputs were provided by the project as a gap-filling strategy, important achievements were in the area of community organization and institution building. Firstly, a Gramin Resource Management Association (GAREMA) was established with membership of all 45 households. Eleven executive members were elected and a revolving fund begun which, at the time of the case study visit, contained about Rs 90,000. From the revolving fund, the GAREMA made a number of productive consumer loans and loan recovery was 100 per cent. Loanees were willing to pay interest at the rate of two per cent per month. Loanees preferred to pay this higher rate of interest because disbursement was hassle-free and they found it convenient to repay the loan installments locally. A women's self-help group was also established. This group consisted of 27 women who contributed Rs 10 a month. It provided loans to 17 women for knitting sweaters and growing mushrooms.

At the time of the case study visit, the project had practically withdrawn its active p hase from the village; project people were trying to encourage sustainability of institutional arrangements. The main results of community mobilisation were in the following areas.

- Village people had set up their own institutional arrangements for resource management and generated resources in the form of a substantial revolving fund. This had reduced their dependence on other sources of credit such as banks, etc. In the maintenance of accounts, a certain degree of transparency prevailed. The revolving fund is understood to be used with the consensus of all the members of the GAREMA and the experience of recovery was highly encouraging.
- The number of animals was brought down and low quality cows were replaced by buffaloes that were stall-fed.
- Out of 45 families as many as 30 families have installed biogas plants to meet domestic energy needs and obtain better quality manure for their fields.
- The area under improved varieties of agricultural crops went up, increasing productivity as well as production.

Case Study of Misraspatti Village, Dehradun District

Misraspatti is situated at 1,000 m in the Swariia watershed of Dehradun District. It covers over 300 ha and is comprised of five hamlets. The number of households is 101; the total population is 622 of which nearly 45 per cent are scheduled castes. Nearly one-third of the people are literate. The total number of animals in 1994-95 was 894; the number of goats being 396. In this village, most fuelwood was obtained from adjoining reserve forest. Nearly all of the gross sown area of about 180 ha was planted with local crop varieties.

A watershed management project supported by the European Commission was started in 1995-96. The project included, as one of its chosen strategies, a shift to improved crop varieties in more than half of the agricultural area. For this purpose, mini-kits, chaff cutters, and other implements were distributed. The total number of cattle was brought down and goats were practically eliminated.

As a result of large-scale afforestation of fuelwood species and other silvi-pastoral activities, the fodder situation was converted from deficit into surplus and farm incomes improved. Village water channels were repaired and improved. This was the result of decisions taken during the first participatory rural appraisal exercise. About 40 small stone checkdams, 17 crate-wired dams, and 21.5m of side walls were built to check soil erosion and improve the water regime.

A Gramin Resource Management Committee (GAREMA) was set up. In the Executive Committee of the GAREMA all five hamlets are represented. The GAREMA had Rs 55,000 at the time of the case study visit. As a result of decisions taken by the GAREMA, the number of cows was reduced by about 30 while the number of buffaloes went up and stall-feeding was adopted. Seven *gobar* gas plants have been established. A women's self-help group has been established but is not successful. Just 13 women joined and they could collect only Rs 2,600. A single loan of Rs 1,800 was given to a beneficiary for purchasing ginger seeds. From the GAREMA fund, 18 people have been given loans amounting to Rs 17,000. All these loans are for ginger seeds: ginger is an economic crop for the village. Village women cut grasses in the forest for which a fee of Rs 50 per family is charged; this has resulted in Rs 2,300 for the village fund.

In Misraspatti, the plantation programme has succeeded while capacity-building of local institutions has been only partially successful. Villagers recognise that soil erosion has been reduced, but increase in plantation cover has increased the threat of wild animals. They complained that animal health-care facilities were missing, and access to reserve forests for wood needed for making ploughs has been restricted. Also, following the withdrawal of the project, difficulties have been experienced in sustaining both the GAREMA and the self-help group. A positive aspect has been that the village has shifted from open grazing to stall-feeding and has achieved greater biomass and crop production. A problem the village has solved was that of the traditional passage of transhumant animal herds. People made collective representation and were successful in stopping itinerant animal herds from passing through their village while moving from the foothills to higher regions each year.

Water Storage in Mountain Areas

The precipitation pattern in the NWHRI is informed by acute seasonality. This seasonality becomes less acute to the west. Even so, it is a dominant feature of the incidence of annual rainfall. Floods in recent decades have become more acute and incessant in India. Most of these are caused by the Himalayan rivers. Unfortunately the major thrust of control programmes has been on the channel p hase of floods, namely, river training, construction of spurs, emban kments, bunds, barrages, and channels. The land p hase of floods has not received the attention required; namely, soil conservation, afforestation, soil-binding grass cover, land treatment, and water storage. This last is admittedly controversial but demands consideration. Building dams (especially large ones) has many negativities but, against the background of the monsoon precipitation cycle, the need for improving supplies of water in non-rainy periods, and the need for tempering floods, this option has to be considered. Another issue is production of hydel energy that could be used to meet the existing acute need for electricity. Dam construction in mountain regions must be made safe and environmentally secure. This can be done by selecting locations, sizes, and designs carefully; by giving priority to catchment area treatment; and by adopting humane and generous re habilitation policies in favour of those who are displaced.