IV. Management of Water Resources

The Doon Valley is a water-rich valley in terms of the total precipitation. Yet, it has always been a chronically water starved valley in the pre-monsoon months. Conserving the abundant downpour during the monsoon into increasingly higher levels of sustainable and perennial water resources, especially in the pre-monsoon summer months, is the central challenge in the management of water resources in the valley. The actual amount of water needed for domestic, field irrigation, and industrial purposes is only a fraction of the total precipitation.

On an average the annual volume of water precipitated in the valley is about 3400 million m3. Apart from the real loss of water from evapotranspiration, the total volume of water that runs off is about 2,000 million m3 (Korsun et al., 1984). The current real total consumption of water for the Dehradun urban area, calculated on the basis of a recent survey (Shiva and Bandyopadhyay, 1985), is about 0.2 percent of this enormous volume. Even if one adds the industrial consumption of water to this figure, it does not change in any meaningful way. The amount of water needed for irrigation has never been quantified inspite of it being the largest consumer of water. A gross estimate of the total annual water requirement would be about 100 million m3, which is approximately a negligible five percent of the annual run-off. This clearly indicates that in terms of the annual water balance there is no reason for a shortage of supply from the internal sources in the valley, even if consumption increases considerably.

In this respect the temporal changes in water supply, in the Doon Valley, are representative of many parts of the Eastern and Central Himalayas that have a heavy monsoon rainfall. Even in places like Cherrapunji, located in Eastern India, receiving an average annual rainfall of more than 10 metres, water shortage in the pre-monsoon period has become a common problem. The evolving crisis is due to a mixture of meteorological, ecological, and human factors that have led to an increased scramble for a shrinking resource base.

This conflict between high demand and low supply of water in the Doon Valley was noted by Baker (1886)more than a century ago, and he commented that:

> *water is very scarce in Dehradun itself in the hot months. The canal is the lowest when the demand is the highest*

Until today, the history of water resource management in the Doon Valley has been characterised by innovations to ensure an increasing supply to meet an increasing demand. No other sector of resource management in Doon Valley is as essential as water for its continued economic development. Paradoxically, the limits to growth in this rain rich valley do not emanate from the scarcity of non-renewable fossil fuel, but from renewable sources of water.

Resource Management in a Historical Perspective

With time, the demand for water has grown and the technological level of human interventions has changed accordingly. The beginning of this intervention started with the tapping and canal transportation of water from the springs originating in the Mussoorie hill area. The existence of a number of springs in this area is normally attributed to the karst limestone belt that acts as an aquifer.

Almost every village on the southern slope of the Mussoorie hill had developed their own irrigation facilities by tapping these mountain streams; many of which carry a lot of water. This technology was not applicable to the villages at the foot of the Mussoorie hill. The geology of the valley is such that as soon as these streams reach the level of the foot hills, and touch the Doon or the boulder bed in the valley, the surface water disappears, percolating through boulders, and shows up again at the bottom of the valley where it oozes out to form rivers such as the Suswa or Asan.

The earliest settlements in the valley (e.g. Nuwada) grew around sites where drinking water from dug wells was easily available. The wells at Nuwada are centuries old and are still a source of domestic supplies. At that time the wells did not hold sufficient water to be used for irrigation. To have access to higher volumes of water the inhabitants of the valley employed an ingenious method of diverting the water through masonry channels just before it enters the boulders at the foot of the hill. The oldest canal constructed on this principle is the Rajpur canal and it supplies drinking water to Dehradun from the head of the Rispana torrent. Rani Karnavati, who administered the valley from the village of Nuwada, on behalf of the Garhwal King, is usually credited with the construction of this canal.

The British were quick to understand the potential of masonry canals for tapping the Himalayan waters. In 1837 the newly formed canal department commenced construction on a new canal using the water of the Bhitarli and Kiarkuli rivers from the village of Bijapur downwards. It was completed in 1839. The next project was the restoration and improvement of the Rajpur canal during 1941- 44. To irrigate some excellent farms and tea gardens in the far-western parts of the valley, a canal diverting the water of the perennial Yamuna at the village of Katapathar was designed in 1941 and constructed a few years later.

During the 1850s and the early 1860s, two other canal systems were constructed. The Kalanga canal was drawn from the upper Song river near Raipur, and the Jakhan canal was drawn from a Himalayan stream of the same name near the village of Bhogpur about 25 km east of Dehradun. Besides these government canals, several small, private canals also provided irrigation. There has been a continuous increase in the area irrigated by canals but the five canals built by the British still continue to be the backbone of Doon's irrigation and provide, even in the 1980s, about 80 percent of the total irrigational needs of the valley. They provide water to 15,608 ha of land out of a total of 19,500 ha under irrigation. The area irrigated has increased continuously from the early days of British rule to the 1980s, and the relative augmentation of irrigation from these canals is shown below.

Year.	1845	1860	1870	1910	1980
Acres.	7500	10,500	14,000	20,000	47,500

Until the 1860s, the expansion of irrigation facilities was based on the tapping of major streams and the physical expansion of canals, while during the last 130 years the growth has been more dependent on better distribution and management as well as the tapping of smaller sources. Baker (1886) aptly described the economic role of these canals:

> *these canals, insignificant though they appear at first, are the greatest blessing to the district. In fact the people depend almost entirely on them for water for drinking and domestic purposes and for the cultivation of all the more valuable crops.*

The Crisis of Urban Water Supply

As the urban areas increased, water supplies to these areas became an important element in water resource management. The story of urban water supply is that of a continually growing unsatisfied demand. With the rapid growth of urban areas in Dehradun and Mussoorie, separate arrangements for water supplies became the responsibility of the respective city boards. The Nalapani springs were the first to be tapped for Dehradun in 1889, reportedly to supply water to the European settlers. When the city requirement increased in 1895, the Kolukhet spring below the town of Mussoorie was tapped for piped water supplies. During 1935-36 Dehradun needed more water and this was provided by diverting the flow of the Kalunga canal. Until that time Dehradun had been fed by gravity sources. On the other hand, Mussoorie was fed by pumped water right from the beginning due to its location at the ridge. In 1908, the Murray pumping station was started and, in 1913, as the demand for water in Mussoorie kept on increasing, the Mackinnon springs were pumped up. In 1925 the Bhilaru pumps were installed and in 1929 the Koltikhala was pumped for the Landour area. The much older town of Rishikesh, being located on the river Ganga, never had any serious problem with water supply. During this period the Irrigation Department, which was responsible for the management of all surface flows, was able to supply sufficient water for domestic use to the township of Dehradun.

The use of water resources, however, went up in keeping with the pace of urbanisation, the extension of the canal system in the valley, and improvments in their linings. After the drastic increase in the urban population,

following the events of 1947, requirements could not be satisfactorily met and the irrigation department was torn between pressure from the rural sector for irrigation supplies and the demand of the urban water supply systems. It became clear that the requirements had exceeded the limits of perennial (lean) surface flow in the valley. This led to the search for larger amounts of water from underground, and the realisation that, unlike with other supply systems, a specialised knowledge was needed. This created the need for hydrogeological information on the groundwater potential of the valley.

The geological origin of the Doon Valley has provided it with a high quality aquifer called the Doon Gravels. These occur below the surface at varying depths and are recharged by the annual rainfall. Probably a certain amount drains out along the flows of the Suswa and the Asan into the Ganga and the Yamuna respectively. The Doon Gravels provide potential aquifers that can substantially augment the water resources in the valley. During 1961-62 the "Dehradun Water Supply Reorganisation Scheme" was prepared and one tubewell was constructed. This, however, was not successful. In the years to follow new source finding, based on the use of tube-wells, was continued, and the conjunctive use of surface water available in the canals and groundwater from a few successful tubewells was somehow capable of satisfying the basic needs of urban areas and irrigation.

In 1971-72, the responsibility for water supply was taken away from the City Board and given to the Jal Sansthan, an organisation dealing with water supply alone. More recently another organisation, Jal Nigam, was established with the objective of source finding and constructing water works, while running them has remained the responsibility of the Jal Sansthan. In a period of increasing environmental consciousness and holistic management, the management of a single resource, water, has thus become the business of three independent executive organisations, namely, the Irrigation Department, the Jal Nigam, and the Jal Sansthan.

The Jal Nigam has tried to plan to meet the future water requirements of the growing urban areas of Dehradun and Mussoorie. On the other hand, since only about one-fifth of the total agricultural land is irrigated, there is constant pressure on the irrigation department to expand the facilities and the water supply over a larger area. It now seems certain that groundwater potential needs to be tapped as the main resource, at least for urban supplies. The Jal Nigam has attempted to determine the urban water requirements for the coming decades and has proposed various projects to make up the shortfall. Table 5 gives the projections made by the Jal Nigam for Dehradun.

Challenges in the Management of Water Resources

The shortfall in urban water supplies, as described in Table 5, may not seem very significant quantitatively when compared with the total water precipitated in the valley. Nevertheless the scarcity, especially during the

Table 5: Projected Water Requirements and Shortfall in Dehradun Urban Area (Million Litres per day)

	YEAR		
Requirement	1995	2001	2011
Domestic (200 lpcd*)	84.20	100.00	127.00
Industrial	10.00	15.00	15.00
Total	94.20	115.00	142.00
Supply from Existing Sources	72.04	62.15	45.75
Deficit projected	22.16	52.85	96.25

* Litres per capita per day.

months of May and June, may soon be a limiting factor to continued economic growth. The scarcity of water may be the dominant factor for a ceiling in the carrying capacity of the valley. The challenge of improving water supplies during the lean period has to be understood and approached through the three specific parameters listed earlier.

The specific socioeconomic parameters of the valley are such that the demand for water has increased in leaps and bounds, over the last century, at a rate that is orders of magnitude higher than an average rural mountain area. The historical trend of irrigated agriculture continues to demand more and more water. In fact, during the months of acute scarcity, distribution of water for irrigation invariably becomes an issue of social conflict for which the Irrigation Department has few coping mechanisms. The increasing demands of urban-industrial areas further complicate the problem. In the absence of clearcut priorities in water supplies, it is reported, political pressures often become the basis of decisions. The solution lies in long term water planning and budgeting by all the dominant sectors using water.

The question of long-term budgeting for water comprehends all the ecological characteristics of the Doon Valley. Before the specific environmental parameters came into focus, the solution to the decrease in water supplies was found in supply augmentation. A proposal for water resource augmentation, from 1995-2011, to the extent of 200 million litres per day has been made. This proposal involves the construction of a dam, on the perennial river Yamuna, on the boundary of the valley at Lakhwar. This idea of making a rainfall rich area depend on the scanty snowmelt flow from an external river was criticised, on the grounds that augmentation of water supply to the valley, from outside sources, is not feasible at all and will lead to a negative economic impact (Bandyopadhyay et al., 1983). This set the trend for looking into ecological characteristics to enhance perennial watersupply to the valley from the sources within.

This inward looking quest has emerged in two directions. Firstly, in the improvement of the hydrological characteristics of the southern slope of the Mussoorie hill in order to reduce run-off, enhance recharge, and increase the perennial stream flows. The efforts of the scientists at the Central Soil and Water Conservation Institute, at Nalota Nala, have shown that, by proper land management in the catchments, the base flow of streams can be substantially improved. Scientists, particularly geologists, of the Oil and Natural Gas Commission, are attempting to locate suitable sites for small dams in the foothills, in order to facilitate groundwater recharge and surface water storage.

Both these efforts can make major contributions to the management of water resources in the valley. In the decades to come, with an increasing demand for water, the valley's dependence on water will shift from surface flows to groundwater. However, the close ecological links between precipitation and surface flows, surface flows and recharge of the groundwater, should be examined from the perspective of specific environmental parameters to ensure that higher rates of groundwater exploitation remain within the limits of sustainable water supplies. The basic challenge, then, lies in introducing new processes or strengthening the existing ones for the storage of rainwater in the natural aquifers. The upper aquifers in the Mussoorie hills seem too small compared to the total requirements, and the idea of using the Doon gravel aquifer deserves serious attention (Jones, 1989).

This naturally leads to the specific institutional parameters as a background for identifying the innovations needed in the institutional framework for water resource management. Bandyopadhyay (1989) has stressed the urgent need for ecological management of water resources in India to avoid fresh water scarcity. The Doon Valley provides an excellent testing ground for initiating the process of institutional integration to address this challenge. There is a lack of coordination in the management of Doon's water resources, as there is in many other areas. If institutional integration is to be comprehensive, the management of water resources should have only one single administrative structure. At present, the irrigation department manages the canals, the Jal Nigam manages the augmentation of domestic and industrial supplies, and the Jal Sansthan looks after day to day water supplies. There are chances of frequent inter-institutional conflicts over the sharing of water and over the division of responsibilities. This is particularly so in the case of surface water sources because they are easily accessible.

The nature of the institutional conflict is exemplified by two news items in the local newspaper. In one, it is reported that the Jal Sansthan wanted the Union Department of Environment to take over the water treatment plant in Dehradun to ensure better service and appropriate handling of the machinery. In the other, it is reported that rivalry between Jal Nigam and Jal Sansthan is the main cause of water crises in the Doon (Himachal Times, 1983).

The future agenda for water resource management in Doon Valley could be very interesting and important. At the level of specific socioeconomic parameters, long term projection of water requirements is a necessity. Agriculture being the biggest consumer of water in the valley, efforts to use it more efficiently will help in extending supplies to more areas. At present the area covered by irrigation constitutes about 44,000 acres only and there is scope for much more. At the ecosystemic level, a quantified ecological understanding of the hydrological cycle in Doon Valley is necessary to examine the prospects of ecological intervention in conservation. At the institutional level, amalgamation of water resource management into one administrative framework, linked effectively with research on hydrology and hydrogeology, has great prospects. If these challenges can be faced by the local people, as well as the administration and the research institutions in the valley, this will constitute a major contribution to water resource management in the Doon Valley and to the Himalayan region as a whole.