CHAPTER-V

RESULTS
AND
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This chapter covers a brief discussion on the results of present study to assess the availability of surface water resources in the study area. It deals with climatic change scenario, climatic water balance and annual rainwater harvesting of the study area. The potential use of the rainwater harvesting structure is suggested on the basis of climatic water balance in the study area. On the basis of investigation for alternative sources of surface water resources, the most reliable option is the integrated water resources development in the study area and is also presented in this chapter.

It is reported by IPCC (2007) that global GHG (green house gas) emissions due to human activity have grown since pre-industrial times, with an increase of 70% between 1970 and 2004. Global atmospheric concentrations of CO₂, methane (CH₄), and nitrous oxide (N₂O) have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice core spanning many thousands of years (Sengupta, 2008). The average global temperature went up by about 0.74°C during 1906-2005. It is observed that for every degree of global warming will add an additional 7 percent of water vapour, which is a very strong greenhouse gas. It is from such first principles that carbon dioxide is going to increase the global temperature. It is predicted that 0.5°C rise in winter temperature would reduce wheat yield by 0.45 tonnes per hectare in India (Panchauri, 2007). Global warming will trigger large-scale devastation in the form of coastal flooding and inundation, rise of sea level, extreme precipitation patterns leading to inland flooding, increase in natural disasters such as hurricanes and cyclones, incipient summers in colder areas, and cooler summers in naturally warmer climates. Global climate change and atmospheric pollution could also have an impact on freshwater resources and their availability in the future.
The study area experiences changes in rainfall patterns, evaporation and potential evapo-transpiration (PET) in the last four decades. From the analysis of mean annual maximum and minimum temperature of the study area over a period of 49 years (1957-2007) with the exception of 1998 and 1999, it is observed that the mean annual maximum and minimum temperature increase to 0.15°C and 0.87°C with respect to LTM while temperature data of the same period shows a rise of 0.57°C in winter, 0.1°C in pre-monsoon and 0.5°C in post-monsoon periods. The monthly mean maximum and minimum temperature distribution over the past 49 years reveal that the hottest month is June with mean maximum temperature of about 29.09°C (>22°C) and the coldest month is January having mean minimum temperature of 4.16° (-0.3°C and 18°C). Thus, the study area fulfills the criteria for the sub-tropical monsoon type of climate as Manipur falls under the same climate condition. It also shows that the study area is reeling the effect of rise of temperature due to global warming.

The floods and droughts of India are related to El Nino events. It means ‘the little boy’ in Spanish, is an abnormal warming of the Pacific Ocean. Normally, the temperature of surface water in the western Pacific Ocean is 6°-8°C higher than in the eastern Pacific Ocean. But during El Nino, this reverses, changing the atmospheric pressure on either side of the Ocean. “El Nino events with warmest sea surface temperature anomalies in central equatorial Pacific are more effective in focusing drought-producing subsidence over India than events with warmest sea surface temperature in eastern equatorial Pacific,” says K Krishna Kumar of the Pune based Indian Institute of Tropical Meteorology (IITM). It can be said that the occurrences of floods and droughts in the study area are also related to El Nino events in the Pacific Ocean (Gupta, 2006). There were floods in 1966, 1976, 1983, 1991, 1992, 2000 and droughts in 1972, 1978, 1979, 1981, 1984, 1993 and 2004. Under these
circumstances, the status of surface water resources in the study area will be subjected
to stress during the coming years.

Thorntwaite-Mather soil water balance model is applied for the construction of
monthly average soil water balance in the study area. It is utilized for the estimation
of monthly average availability of surface water resources in the study area. It is
observed that there is availability of surplus quantity of water in June, July and
August but it flows as runoff to major rivers such as the Imphal, Irl and Nambul
without any effective utilization. It results in unavailability of sufficient quantity of
water during lean season. After the monsoon season (June-September), the deficiency
of water takes place during the months of November to March along with soil
moisture utilization from November to February. It is because of these reasons that
double cropping is not possible in these months in the study area. During the months
of November-February, the potential evapo-transpiration (PET) is more than
rainfall. The total annual PET of the study area is estimated as 118.17 cm. The soil
moisture recharge takes place alone in the months of April to May. This natural cycle
is repeated every year from the last many decades and actions are needed to conserve
the precious water resource.

The study area is mainly made up of impervious and pervious areas. The
impervious area is concentrated in the municipal area and the pervious area is mainly
found in the non-municipal area. The impervious area generates more runoff as
compared to pervious area due to higher run-off coefficient. A correlation coefficient
of 0.60 between rainfall and runoff has been computed from the analysis of annual
rainfall records for 49 years. In addition to this, the study area possess a large number
of water bodies such as lakes, tanks, ponds, wetlands, etc. and these water bodies
preserve water for usages during lean season. From the analysis of climatic water
balance of the study area, the annual surface water surplus of the basin occurs in June-
August and is the sum of "Excess water from Thorntwaite + Mather soil water balance
+ Interception (including water bodies) + Average runoff). It is estimated that the annual rainwater potential of the study area is 3596.83 MLD. It will provide as an additional source of water to the conventional source of water. The harvested water can be utilized for various usages during lean season.

Wastewater of the study area is at present discharged into the river, yet reclaimed wastewater has several non-potable uses. When it is mixed with river water, the natural process of dilution, filtration, adsorption, sedimentation and biological activity, which is efficient in killing pathogenic bacteria, may be inefficient or not function at all due to increased loads and too much short time. The freshwater resource of the study area is becoming acute day by day. Whenever possible, wastewater should be treated at the source to minimize its adverse impacts on the environment. This is a more practicable alternative to alleviate the present water supply problems. In addition to this, the flow of sanitary wastewater is mainly affected by the factors such as rate of water supply, population, type of area served and ground water infiltration. The quantity of wastewater generated in the study area in 2007 is 47.12 MLD and the projected quantity of wastewater in 2011, 2021 and 2031 are 52.08 MLD, 66.88 MLD and 85.89 MLD as shown in Table A-I (5.1). The generated quantity of wastewater must be treated upto tertiary level for its usages for non-potable purposes.

The Imphal water supply is based on supply management system in which anticipated increases in water demand of the area have been matched with increases in the amounts of water available for supply augmentation projects. It is mainly concerned with the exploitation of new water supplies to meet the water demand. A combination of supply and demand water management system is proposed for the improvement of Imphal water supply system. Its problems involve determining the construction completion dates of capacity expansion and demand management projects to optimize two criteria. The criterion of supply management involves
minimization of the present value of the cost of implementing projects and the
criterion of demand management involves minimization of the expected value of costs
to cope with emergencies in the supply of water.

Drought conditions prevailed in the study area during in 1972, 1978, 1979,
water conservation techniques and optimum utilization of available water resources to
tackle the problem of water scarcity during these days.

There is a growing concern over the need to conserve water in the study area
because of the rapid growth in population and urbanization. The main benefits of
water conservation are general sensible use of natural resources; ability to serve more
people with the same capacity; and overall economic savings to the consumer. The
economic savings include delay in construction of a new supply, treatment facility or
distribution system can be postponed to a numbers of years and operation costs are
reduced. Programmatic measures include Conventional and Non-conventional
methods to meet the growing demand for water. The Conventional method includes
augmentation of Imphal water supply. The Non-conventional method could save a lot
of potable water that is used for non-potable purposes in addition to saving in energy
and money. Conservation programs must be successfully implemented to reduce
demand and thereby provide time to augment supplies. We can easily save significant
amount of water at little or no extra cost and will eliminate the demand-supply gap by
the year 2031.

Water conservation practices can be applied successfully in a number of areas
in the study area for a variety of beneficial uses. These practices are used to reduce
water demand, moderate peak consumption to delay or avoid capital expenditures of
water system expansion, and reduce the effects of water consumption on the
environment. The successful implementation of a large-scale water conservation
program mainly depends on public awareness of the need for conservation and how
conservation is perceived as a workable alternative to traditional development of new water supplies. One of the first points to determine is how public awareness and attitudes towards water conservation and policies are influenced by the sources in which people rely on to gain information. This would involve conducting public awareness programme to make them aware of the need for conservation. Another important question is how certain conservation measures and policies are likely to be more readily applied than others, especially in the residential or municipal sectors. These factors must also be considered within the context of institutional arrangements and the economics of water resources development.

The unreliability of water supply has a great impact on our society. It affects our daily life, economics of the industry, as well as our households. It affects the health and morale of all of us in this society. Population and economic growth, and greater appreciation of the value of water in ecosystems, means that water demands are growing and shifting. Shifting patterns of precipitation and runoff associated with climate change compound this gloomy arithmetic. An inability to predict and manage the quantity and quality of water and the impacts of droughts, floods and climatic variability imposes large costs on many economies in the developing world. Effective development and management of water resources are essential for sustainable growth and poverty reduction in all developing countries. Usually, the percentage of population with access to potable water is considered a relevant indicator of the progress achieved in supplying water. Rainwater should not be neglected in the effort to provide water. Because of its unique advantages of technical simplicity and convenience, rainwater catchments can make a major contribution to supplying the water needs of many people.

To prevent further depletion and degradation of freshwater resources, a more holistic approach is known as Integrated Water Resources Management (IWRM). It is a key approach that must be taken up by policy makers and political decision makers...
to ensure optimal and sustainable use of water resources for economic and sustainable use of water resources for economic and social development, while protecting and improving the ecological value of the environment. Methods include water conservation and reuse, rainwater harvesting, and wastewater management (Karthikeyan et al., 2003). As the overall quantity of water in the study area cannot be altered significantly by human actions, freshwater resource has to be regarded as a natural capital asset and hence to be used in a judicious manner to optimize the benefits for the community. In a situation of competition for scarce water resources, there are instances of low value uses such as leakage and wastages of water in the water distribution system and no incentives are provided to treat it as an economic good. There is an urgent need to recognize water as an economic good. It is suggested to integrate potable water supply, rainwater harvesting and reclamation of treated wastewater to augment the available water resources of the area. In the future, increasing demands for water will be met by managing existing water resources more effectively and not by creating more water supplies.

The State of Manipur is endowed with abundant water resources as compared to other States of India. However, the resource is solely dependent on rainfall that is seasonal in nature. The Govt. of India has already formulated National water policy for the first time in 1987 and it has been further amended in 2002 in view of the urgency of managing supply and demand of water to handle water crisis in the future. However, Manipur is lagging behind of other States in adopting the water policy. The availability of freshwater resources in the state also decreases due to decline in the rate of annual rainfall coupled with increase in temperature, rapid growth of population, urbanization and industrialization. Therefore, it is highly needed to frame State water policy for sustainable development of freshwater resources in Manipur.