PREFACE

Water is among the most basic necessities that nature has provided to sustain life on earth. Most of us are conscious nearly every time of the importane of water in our life but truly our idea regarding this is very meager. Now a day, normally water outstresses all geoenvironmental factors to enter more confidently into considerations of human and economic development and quality of environment. At present, we have to realise that rapid measure of demand for water, degradation of water due to pollution, chronic water shortages in Cities, increasing incidence of water borne diseases etc. are becoming order of the day. As we exercise more growing complex problems of economic development, environmental quality, population dynamics, resource management and disaster mitigation, less emphasis is being placed on the study of groundwater potential, its quality and utilization across the country. Hence, a sound understanding of the water resource potential, quality, demand and supply is becoming increasingly essential especially in the geoenvironmental sciences. It is important to appreciate the fact that only 3 percent of the world's water are fresh and roughly one-third of it is inaccessible. The rest is very unevenly distributed. On one hand, water is used with abandon; on the other hand, sufficient supplies of water have become increasingly contaminated with wastes and pollution from industry, agriculture and households.

Over the years, rising population, growing industrialization and expanding agriculture have pushed up the demand for water. Fortunately, India is blessed with a comparatively large potential of groundwater resources of the earth. The groundwater reservoir contains the largest storage of fresh water in the country-far more than the capacity of all surface reservoirs. A total groundwater potential stands at 453.42 km^3 per year in India. Whereas, the annual per capita availability of renewable fresh water in the country fell from around 5277 m^3 in 1955 to 2464 m^3 in 1990 (Engman&Gurney, 1991). Per capita water availability in 1947 is estimated to have been 6008 m^3 a year, which has fallen to 2266 m^3 in 1997. This gives a broad indication of the growing scarcity in the country in the fifty years

since independence. The figure for net draft of groundwater considering the present level of utilization indicates that substantial portion of it, 70 percent remains to be tapped (CWC, 1995).

A well marked special in equality occurs in the infrastructure set up and development in India. To remove this inequality backward regions are developed on a priority basis, which calls for an assessment of their resources and drawing up of plans for the optimum utilization of the resources. The present research analysis is a humble attempt in that particular direction for launching the 'Terai' region (covering an area of Mechi-Mahananda interfluve) of Darjiling district in the 21st Century. Practically, development of water resources should form an integral part of the regional development plan since water is intimately associated with urbanization, industrialization and agricultural development.

India is the most extensively irrigated country in the world and irrigation from wells, tanks & ponds, canals, rivers & jhoras etc. dates back to time immemorial. This irrigation is highly independent on account of uncertain monsoon rainfall regime of the country. Since, the attainment of independence in 1947, the Govt. of India has paid special attention towards the development of irrigation to make the country self-sufficient in food. The financial positions for the same has been increasing from one five-year plan to the next. Though water is essential for survival, but today about 200 million people in India do not have access to safe drinking water. Most of our water sources are polluted with untreated or partially treated wastes from industry; domestic sewage and fertilizer or pesticide runs off from agricultural fields. It could be assumed that at the time of independence, piped and treated drinking water was available only in cities and only to 48 percent of those who lived in them. At the end of 1991, the figure was 86 percent. And by 1994-95, as much as 82 percent of the rural population was covered (CWC, 1996). Currently, about 81 percent of the countries of total population have accessed to safe water (CSE, 1997). As the country has a long tradition of managing water, but increasing demands due to population and industrial growth and agricultural development pose new challenges. The quantity and quality of available water is decreasing, aggravating the already serious position. A multi-layered approach, which involves implementation of legislation,

introduction of new and traditional technologies for water conservation, recycling and reuse, economic incentives for users and the involvement of people who have a stake in the use of the resource are required.

The present research work has grown out of the author's Ph.D. Thesis. Every attempt has been made here to incorporate all the relevant material that became available since then with respect to the area under study or even from outside. Though, the limitations were many regarding the geographical and administrative; lack of equipment for individual aquifer testing proved a serious handicap in the assessment of the aquifer potentialities while the restriction on the number of boreholes did not permit the drilling here and there, hence, only that has been included which was found to contribute materially towards a better understanding of the hydrogeology of the study area through the air photographs and landsat imageries and previous wells done by PHED and CGWB respectively. For instance, the new field and laboratory data obtained in the course of a recent study by the researchers has also been taken into account hereby managing all shorts of problems. A brief review of the work done in other parts of the world, in particular aspects of the research, has also been given to make the present work more comprehensive.

The study and systematic investigations of groundwater potentiality, quality and management of the 'Terai' region of Darjiling district located at the Mechi-Mahananda interfluve have been included under the present research work. The factors, significantly affecting the occurrence, distribution, movement, quality, proper assessment, utility and development of groundwater are studied in details and the discussions of the results are put under different heads. A detailed work of this nature had not so far been undertaken in the district.

The area is suited for a study of this nature as it presents a combination of almost all the conditions likely to affect the occurrence, distribution, movement, recharge to, discharge from, aspects related to water quality evaluation, perspective planning for development and management of aquifers in this region. For instance, the effect of influent seepage from surface water bodies, including streams and canals and of intensive pumping from a large number of tubewells, can be studied here in details. The data in sufficient amount are available as

regards rainfall, evaporation and transpiration, soil moisture, surface run-off etc. Whereas, data as regards hydrogeologic properties of water-bearing materials, water table depths, well logs, groundwater flow etc. is very meager. Further more, the available data are almost all in an unpublished form scattered over a large number of offices and their collection, becomes very impedimental and time consuming.

Under the present investigation, an intensive fieldwork has been undertaken in the area for studying the topographical, geological and hydrogeological features. In this connection, the measurement of water table depths, canal and wells discharges, physical and chemical test for water quality was undertaken. Further core-samples of deep tube wells borings were collected for studying their mechanical analysis as well as their hydrogeologic properties.

The total research work has been divided into ten chapters. The Introduction deals with the history and development of groundwater potentiality in study area. The names of the authors who are the main contributors of the subject have also been mentioned therein. It also includes the location and extent, the previous investigations, the period covered, the scope and the methods of investigation.

Chapter-I is related to the physical setting of the area including drainage, climate and climatological water balance, soil, vegetation types, forests, agriculture, natural resources, occupation of the people and landuse. Chapter-II entitled geology, which deals with the surface, and sub-surface geology of the terai region of Darjiling district. The major part of the study area lies in the foothills of Darjiling Himalayan range, whereas, only a small part in the southern portion of the study area lies in the Gangetic plain, hence the geology of the area is very complex. Chapter-III is related to a study of the sources, distribution, means of supply and assessment of water resources. It reveals the techniques of analyses have been discussed for the measurement of magnitude of area and shape, relief, linear properties and hydrological characteristics in relation to the morphological parameters. Chapter-IV gives the results of the mechanical analyses of deep tubewell samples, collected in the course of drilling from 12 tubewells situated in the study area. With the help of this analysis, the

hydrogeologic properties of soils and water-bearing materials in the area have been determined. Chapter-V deals with the water table and its fluctuations, which covers the significance of water table, the location of observation wells and their water level records, the depth of water table below the ground, the form of water table and the fluctuations of the water table. Chapter-VI is concerned to a study of the recharge and discharge of groundwater, and the safe yield of the groundwater reservoir. The study is based both on the 'water table' and the 'general inventory' methods, the later also involving a study of the water balance. Chapter-VII deals with the groundwater quality, a topic as important as groundwater quantity, with emphasis on measures of water quality and interpretation of water analyses. Chapter-VIII is concerned with the study of groundwater uses and requirements in different sectors and also discussed the groundwater related problems. Chapter-IX presents the relative importance, scheme and suggestions for future development of groundwater resources. A conjunctive use of the surface and groundwater resources management and various conservation practices, suited to the area, in context of problems met within the area have been recommended. Water consumption and requirements in 2011 AD, in the different sectors of the economy have been estimated for planning the future development of water resources in the area of investigation. The last Chapter i.e., Chapter-X deals with the summary and conclusions derived from the entire present investigations. A bibliography of the works referred to in the thesis just after the concluding chapter that followed by appendix lists.

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