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Research Note

# Groundwater Flow Modelling in Gundar River Basin, Tamil Nadu

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**Abstract:** Ground water is an important source of water for drinking, irrigation and industrial purposes. To maintain a sustainable agricultural production and to arrest the depletion of water table, there is a need for micro level study of groundwater potential. In this work, an attempt has been made to estimate the amount of ground water for the Gundar river basin, which can be used to plan a suitable usage of ground water. Visual MODFLOW was used for groundwater flow simulation in the study. The model when applied to the study area showed the permissible error of ± 10–20% in 87.3% of computed values from the actual values of well heads. The results showed that the flow direction more or less coincided with the general slope and there was an inflow and outflow across the western and eastern boundaries. The coastal alluvial formations showed the intrusion of seawater into inland freshwater aquifers.

**Key words:** Groundwater modelling, groundwater recharge, river basin, water table.

## Introduction

Ground water is a precious, most widely distributed resource of the earth, and it gets its annual replenishment from the meteoric precipitation. The extensive use of groundwater resources in India started during the past three decades and most of the irrigated area and public water supplies are met from groundwater resources. In a tropical country like India, with the availability of surface water getting scarce day by day, the pressure on the next source, viz., ground water is mounting up continuously. In Tamil Nadu, the current situation is very perilous. In most river basins the groundwater level has gone down to unimaginable depths of 250-300 m. Either this situation is due to over-exploitation or poor recharge as a result of monsoon failures. Therefore, a proper planning for the judicious exploitation of ground water in a river basin becomes essential and hence the systematic study or evaluation of groundwater potential on river basin is the need of the hour. To evaluate the groundwater potential in a basin, knowledge of the effects of the numerous variables like rainfall, top soil, topography, land use pattern, subsoil properties like hydraulic conductivity, porosity etc. on the recharge pattern is essential. The values of these variables are also not uniform and vary from field to field and hence the determination of these variables over a basin will be very difficult, if not impossible. In addition, it takes considerable time and money. Therefore, the next possible method is the mathematical modelling.

## Materials and Methods

Gundar, the non-perennial river originates at an altitude of 500 metres above MSL and confluences with the sea at Gulf of Mannar, after traversing about 150 kms. Gundar

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river basin lies in between 9°05″ N - 10°03″ N latitude and 77°35″ E - 78°35″ E longitude, covering an extent of 5647 sq. km (Figure 1).

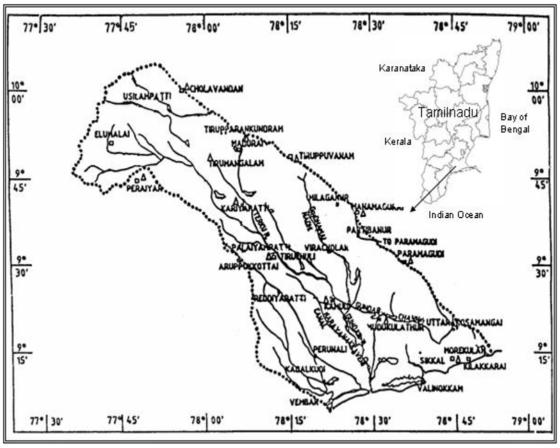


**Figure 1: Location map of the study area (Gundar river basin).**

The area which falls under hilly and mountainous terrain has narrow prospect for the development of groundwater recharge and is 260 sq. km. Thus the recharge area work out to 5387 sq. km. The total water applied varies in time and space as a complex function of many physical and climatological variables. Because the change in soil moisture storage is negligible over extended periods of time, the yearly recharge for the study area was estimated as a function of total applied water and evapotranspiration (Ward, 1971).

Recharge rate = Total applied water – ET

Total applied water = Discharge from the wells + precipitation.

*Step-by-step procedure used for model building*

**Step 1:** The digitized base map was imported to the Visual MODFLOW software. The entire study was divided into grid of 20 rows by 20 columns.

**Step 2:** By using the grid elevation, the elevations of each grid were assigned.

**Step 3:** The observed heads for the observation wells were imported to the corresponding wells, which were stored in Tab delimiter format.

**Step 4:** Hydraulic conductivity, storage coefficient, specific yield and porosity for different area were assigned.

**Step 5:** Recharge and evapotranspiration values were entered for the whole study area.

**Step 6:** Run type (transient state), time step (20), solver (SOR) and output controls were set.

**Step 7:** Finally, the output was obtained both in pictorial and graphical forms.

## Results and Discussion

The model was validated using the monthly groundwater levels (heads) of 65 observation wells of the Gundar river basin (Figure 2) recorded over a period of three years from July 1999 to June 2002. Of the 30 observation wells, the calculated well heads by the model in 27 wells showed a deviation of ± 10–20% from the observed heads. Of the 16 observation wells, the calculated well heads by the model in 14 wells showed a deviation of ± 10–20% from the observed heads. Of the 19 observation wells, the calculated well heads by the model in 16 wells showed a deviation of ± 10–20% from the observed heads. The infirmities in the computed values of the model seem to stem from the difference in the direction of groundwater flow, irrigation practices and variation in recharge rate of aquifer within the study area. Further, the differences probably related to both data deficiency and modelling error. One such source of error is the difference between the calculation date (end of each month) and actual date recording the data. All the above factors contribute to the considerable difference between the observed and computed values of head. Such type of variations were common as reported by Konikow and Bredehoeft (1974). Thus, the permissible deviation of ± 10–20% was observed in 87.3% of computed values by the model. This value (87.3%) is more than the acceptable (80%), particularly for models dealing with ground water.

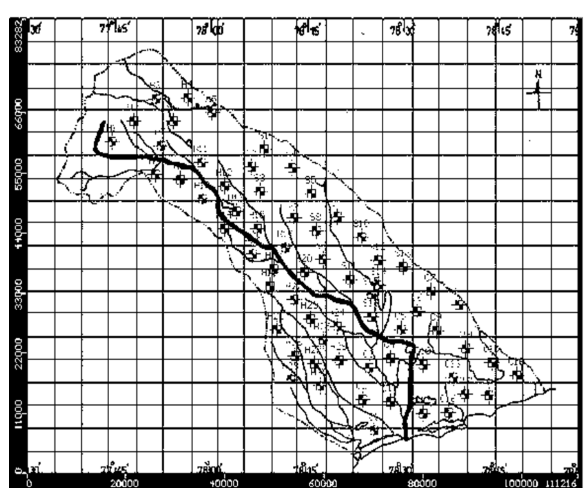

**Figure 2: Location of wells in the river basin.**

## Groundwater Flow Direction

The flow lines more or less followed the general land slope direction. On the eastern boundary of the river basin, the groundwater flow direction in the upper reach of the basin follows the general slope until it reaches the plain hard rock area. Afterwards, there is a change in flow direction resulting in an outflow from the basin. The groundwater flow in a direction will have a horizontal and a vertical component. The horizontal component of flow is accelerated through the weathered zone overlying the impermeable layer in the hard rock surface, which reduces the downward movement of water resulting in reduced recharges. Therefore the horizontal component becomes dominant leading to outflow to adjacent basin. Excessive pumping on the other side of the basin boundary might also induce the horizontal component. Similar results were reported by Bobba (1993) while investigating the freshwater aquifer of Lambton, Ontario, Canada. Another notable feature is the areas infested with saltwater intrusion in coastal alluvial formations. This occurs mainly due to the landward gradient of water table caused by excessive pumping nearer to the seacoast (Ernest, 1979). Hence, the control of seawater intrusion into inland freshwater aquifer is very important in the coastal alluvial belt as a 2% seawater in fresh water would render water unpotable.

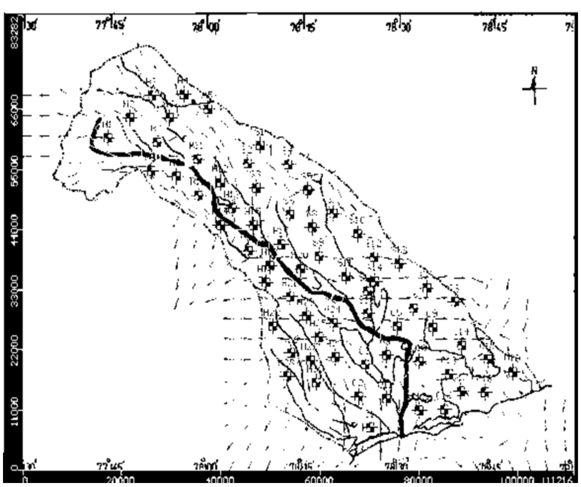

**Figure 3: Groundwater flow direction in the river basin.**

## Water Table Contours

The groundwater potential is more near the river and it occurs at a depth of around 23.0 m. It occurs at a depth of 29.0 m, the deepest in the highest elevated areas of the basin. The water table gradually goes down as we travel from the river to the boundaries within the basin; the contours are wider spaced indicating a lower hydraulic gradient for the groundwater flow (Raghunath, 1985).

The area which lies in the upper side of the river in the lower reach of the basin had 23 m water table contours. This may be due to the transfer of water from the adjacent basin or due to some localized aquifers. This area lying in the middle of the basin had 24 m water table contours, because of its proximity to the river, the water table is considerably influenced by the seepage from the river compared to other areas. These quite obvious and such types of results were reported by Gill (1984). The upper edge of the river basin had high water tables, because of poor recharge due to degraded lands coupled with rock outcrops.

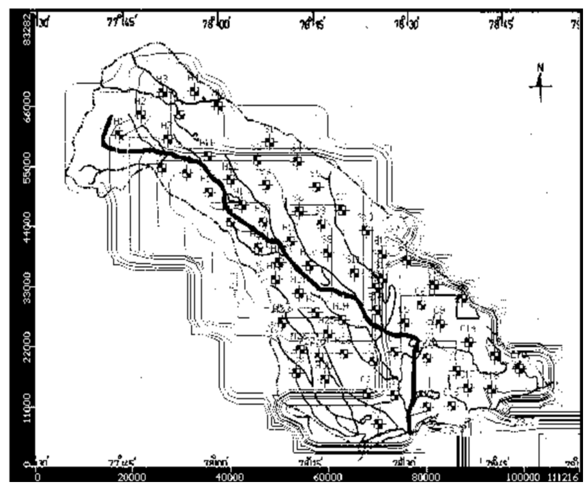

**Figure 4: Water table contour in the river basin.**

## Recharge Contours

The recharge source is surface water from precipitation and, to a lesser degree, from irrigation or artificially

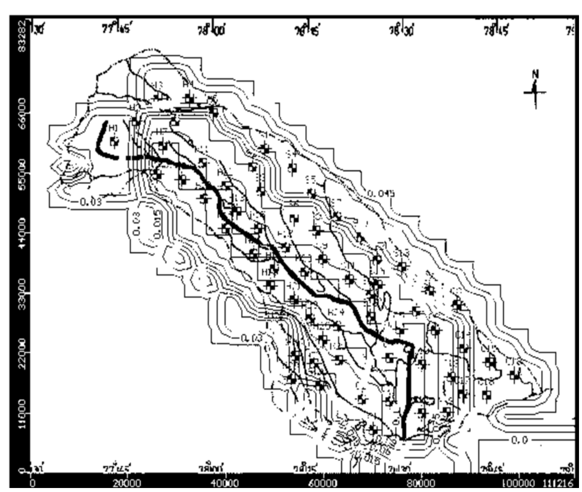

**Figure 5: Recharge contour in the river basin.**

constructed recharge ponds or losing streams. In the river basin, the recharge rate varies from 0.1 to 0 m/month. The areas which were lying on the upper side of the river (sedimentary area and coastal alluvium area) accounts for the maximum with 0.1 m/month. This was due to the influence of porosity and hydraulic conductivity of the area (Morris and Johnson, 1967). In the upper reach of the basin which was hilly or degraded lands with rock outcrops, there was only negligible rate of recharge.

## Conclusion

The groundwater status in the basin is very poor and, hence, suitable recharge methods (natural and artificial) should be adopted in the river basin to increase the recharge rate. This can be done by arresting the water flowing towards the sea as surface runoff by constructing suitable structures at appropriate places. The practical use of the study can be further enhanced by dividing the study area into smaller units (watersheds). By this, the spatial variability in input data can be minimized with little or no error in results.

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