CHAPTER – 6
CONCLUSION AND RECOMMENDATIONS

In this chapter, findings of the research work carried out are summarized and the conclusions emerging from the study are presented. On the basis of the research findings, several recommendations are proposed. The scope for further research in this direction is also outlined.

6.1 Conclusion
To achieve the proposed objectives, various tools and techniques have been used to get the results which were analyzed and compared.

One of the objectives of the present study was to prepare groundwater table map of various time series (pre and post monsoon), rainfall maps and study fluctuating patterns. The ArcGIS Geo-statistical Analyst tool has been used for analyzing spatial and temporal variations of groundwater level fluctuations. The semivariogram modeling has been used to find out the best fit for a model that will go through the points in the semivariogram. It was observed that stable and rational quadratic models have been selected in most of the cases. Cross-validation has been used to ensure "how well" the model predicts the unknown values. The best fitted model for pre and post monsoon water level for the years 2007 to 2014 has been used to generate the spatial distribution maps. Two groundwater level series were produced (pre-monsoon and post-monsoon) and were plotted on the same graph together with annual average rainfall. The major conclusions derived from this study are outlined below:

- Pre-monsoon distribution of water level clearly shows that arid parts of Rajasthan (Thar Desert area) have deep groundwater. The most critical area (water level below 36 meter) is spread over the districts Jaisalmer, Barmer, Bikaner, Jodhpur, Nagaur, Churu, Jhunjhunu, and some parts of Sikar. It is probably due to the combined effect of low rains, high evaporation and evapo-transpiration rates, impermeable gypsum bed at shallow depth, and high exploitation of groundwater for irrigation (Jhunjhunu, Sikar and Nagaur).
• Situation in areas east to Aravali hills is comparatively better as it gets more rainfall and use surface water for irrigation. All remaining areas have average water level with small fluctuations in pre and post monsoon seasons depending upon rainfall in different years, pattern of exploitation, water harvesting systems and land use patterns.

• Analysis of post – monsoon water level shows more or less similar patterns as it was obtained in pre-monsoon period. Areas west to Aravali shows deep water level except few areas of Hanumangarh, Ganganagar, part of Pali & Jalore. In the similar way, the area east to Aravali shows higher water level and good response to rain as it comes up in the post-monsoon season.

• Carefully observing the pre and post monsoon water level maps, it is discernible that water level has a direct impact of rainfall as shown in the post-monsoon water level for the years 2011-2014 and rainfall pattern of the same period. The rainfall in this period remains continuously better than the average and as a result, water level of post-monsoon season in eastern and southern Rajasthan has come up considerably after 2009. The area under water level less than 5 meter was just 3.28% in 2009 and which has increased to 23.63% of the total area in 2013. The water level greater than 85 meter which was around 3.34% in 2007 is reduced to less than 1% in 2014. These figures shows that the area which is showing increasing trend of groundwater level is mostly in the eastern and southern part of Rajasthan where rainfall is high and recharge conditions are also favorable, especially in districts of Udaipur, Dungarpur, Banswara, Pratapgarh, Chittorgarh, Tonk, Bundi, Kota, Jhalawar, Baran. Even in the desert area, the groundwater level has come up in the IGNP command area in entire Jodhpur, Pali and Jalore districts due to canal irrigation, irrigation from Luni river.

In another part of the study, an attempt has been made to identify the suitability of groundwater for human consumption based on computed Water Quality Index in the state of Rajasthan. Prior to this study significant water quality information using WQI was not available for a longer duration for the groundwater quality of the state. In this study, GIS and WQI have been extensively used to identify the zones of suitable water quality in the state.
The important water quality parameters selected for the calculation of WQI were total dissolved solids, sodium, potassium, calcium, magnesium, chloride, sulphate, nitrate, fluoride and total hardness. Spatial distribution maps of WQI for the years 2007 to 2013 were generated for the entire state. The major conclusions derived from this part of study are outlined below:


- The WQI maps indicated that the safest zone was in the South-Eastern part of the study area, where nearly all WQI values of the samples were in excellent class for drinking specially in Banswara, Udaipur, Dungarpur, Partapgarh, Chittorgarh districts.

- Water quality of arid region was found very poor in the entire desert areas on account of low rainfall, low recharge and high exploitation. Ganganagar, Hanumangarh, Jodhpur and Bikaner districts, along the IGNP command area, have shown significant improvement in water quality due to availability of fresh water through IGNP.

- In central part of Rajasthan, especially in Naguar, Ajmer, Bhilwara, northern parts of Bundi districts, water quality remained in poor and very poor category and is also not affected much by rains because these areas are high run-off producing areas where percolation of rain water is very less. Water level in these areas remains more or less the same.

- As per the WQI score, very poor water quality areas are Churu, Nagaur, Jaisalmer, Jalor, and parts of Jodhpur, Pali, Dholpur and Bharatpur districts. All of these districts, except Bharatpur and Dholpur, have a scanty rainfall. It may be
due to high evaporation, evapo-transpiration and deeper aquifer. Groundwater in
the deep aquifer remains stable for a longer time since there was neither any
recharge nor any abstraction of water in these areas. North-eastern area of
Rajasthan covering Bharatpur and part of Dholpur district have poor quality due
to having layers of sodium, potassium and calcium salts in the sub-surface soils.

- Southern Rajasthan covering districts Sirohi, Udaipur, Chittorgarh, Rajsamand,
Pratapgarh have Aravali hills which is hard rocky area characterized by high
rainfall, ground water is comparatively shallow and have good water quality.

- It was discernible that water quality has direct relation with rainfall, recharge
conditions, local sub-surface soil conditions and local Lithology. Areas of
recharge has comparatively better quality of ground water as observed in
southern parts of Rajasthan and IGNP command areas and Ghagger channel areas
in Ganganagar, Hanumangarh and Bikaner districts.

- In general, the groundwater quality decreases from the South-East to the North-
West of the state.

Thus, it can be said that GIS has been proved to be valuable way in understanding and
dealing with the pressing problems of water resources management in the study area.
Water quality index has been proved to be user friendly, easily understandable and more
trustful way than isolated parameters. Geostatistical tools of GIS provide good methods
of generating statistical surfaces from sample point data and also for generation of
distribution patterns of individual parameters and WQI values. These methods also
facilitate integration of various themes such as water level, rainfall, water quality etc.

6.2 Recommendations

- Water quality indices should be used in order to understand the overall water
quality.

- Water quality has close relation with rainfall, run-off and geological formations.
There is a need to study rainfall-runoff model with water quality index so that
entire hydrological mechanism can be understood.
• The overall quality of groundwater is low and this situation needs urgent and strategic solutions.

• It is highly recommended to use GIS tools and its application to produce maps to communicate our tragic water situation to the people working in the state.

• It is recommended that authorities and decision-makers should make polices and mechanisms for efficient management and distribution of groundwater in the study area based on the findings of this study so that inhabitants get improved health and sanitation as well as to avoid environmental degradation.

6.3 Scope for Future Work

• The extensive study can be carried out region wise considering various types of hydrological and hydro-chemical parameters. The block-level analysis could be carried out in this study.

• To develop an ANN model for studying the relationship between TDS and various groundwater quality parameters and predicting the groundwater quality.

• To develop an ANN model for studying the relation between groundwater level and hydrological parameters such as: rainfall, recharge rate, abstraction, evapo-transpiration etc and predicting the water level.