

## ABSTRACT

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Groundwater is an important resource of water for domestic, agricultural, and industrial requirements. It is the principal source of drinking water in rural and urban areas, and widely used for irrigation in the most arid and semi-arid regions in addition to rendering a considerable service for ecosystem and human health. It has also become apparent that many human activities have tremendously impacted both the quantity and quality of groundwater resources. Remarkable depletion of groundwater resources in northwest India, especially in Rajasthan, is the main motivation behind this research work as the depleting groundwater also indicates deteriorating water quality. Northwest region i.e. Bikaner district in Rajasthan is facing severe water scarcity and quality issues since decades.

The quality of groundwater is getting worse due to widespread surface pollution and leachate from improper disposal of solid and semi-solid waste, which becomes endemic to various human health hazards such as fluorosis, nitrate related syndromes and are getting adversely affected due to contamination of groundwater resources. A very few studies have been undertaken in the region and therefore the issues related to the water sector have not been fully addressed in the research domain. Quantity and quality both matters while fulfilling the demand for various purposes such as drinking, irrigation and for industries. Considering the above said quantitative and qualitative issues related to groundwater, this study aims to assess suitability, potential, and sustainability of groundwater resources in the hyper-arid region of the Rajasthan, India.

As ground water is observed as an important source of livelihood in the regions where rainfall is scanty, surface water sources are absent and all domestic, agricultural needs are fulfilled with groundwater. This study has made an attempt to identify the major issues related to groundwater in study area, subsequent to which four different models were developed in order to understand various aspects of groundwater such as the status of water quality, potential zones of groundwater, its sustainability through life cycle assessment (LCA) of groundwater supply system in hyper-arid region of Bikaner block in the state of Rajasthan, India.

In Chapter 3, groundwater quality has been assessed in hyper-arid region using multivariate statistical analysis. A total of 43 samples were collected and analyzed using Principal Component Analysis (PCA) and Hierarchical Cluster Analysis (HCA) to observe the relationship and interdependence amongst the various physicochemical variables contributing to the quality of groundwater. The results of the statistical techniques showed that the variables are in strong correlation with each other. Cluster analysis proved to be a good tool to ascertain the spatial similarity between the contributing variables. The methodology adopted in the present study has been found to be an effective tool and can be utilized to establish a strong water quality monitoring network in similar areas.

With the fast advancement in the area of remote sensing (RS) and geographical information systems (GIS), it has now become possible to make an estimate of the Earth's resources with high accuracy both spatially and temporally. Therefore, an attempt has been made in Chapter 4 to describe potential zones of the availability of groundwater and its quality status based upon the water quality parameters' spatial distribution by applying GIS approach integrated with remote sensing technique. All suitable data has been created by developing thematic layers of critical parameters such as rainfall, land use, soil map, slope, land cover, drainage density, and DEM using Landsat 8 imagery from Earth Explorer (USGS) and other conventional datasets. Groundwater maps have been prepared using GIS by keeping in view of relative importance of thematic layers. The outcomes of the study will allow users to identify, visualize, understand, assess and analyze suitability of groundwater quality as well as quantity. The objectives of this chapter includes: (i) generation of site suitability maps for irrigation and drinking purposes; (ii) development of a methodological framework; and (iii) utilization of the methodological framework to assess potential zones of groundwater, in the Bikaner region in the state of Rajasthan, India.

In order to maintain freshwater resources sustainably, they should be used in an effective and efficient manner without compromising the needs of the future generation. Therefore, Chapter 5 mainly focuses to develop a groundwater sustainability index by taking into consideration of a case study of western Rajasthan, India. The framework for the development of groundwater sustainability index considered five dimensions of groundwater resources defined on the basis of fifteen indicators chosen for the study. Analytical Hierarchy Process (AHP) has been applied in

order to assess the importance of the selected dimensions of groundwater. The outcomes of the study clearly reflect that the situation of groundwater resources in the region are alarming and the future of groundwater resources is at stake. This chapter concludes with the actual status of sustainability of groundwater with particular reference to hyper arid region of Rajasthan by integrating all important indicators related to protection and management of groundwater in the region.

Chapter 6 addresses the life cycle assessment (LCA) of groundwater supply system in hyper-arid region of Bikaner block in the state of Rajasthan, India. This chapter aims to address potential environmental impacts of groundwater extraction for irrigation purpose and sustainable management of groundwater in water scarce regions. To assess the impact of groundwater extraction, the functional unit of the study has been taken as one kiloliter of freshwater withdrawal using submersible water pumps for irrigation purpose. The primary data for the water withdrawal and energy consumption are collected through semi-structured interview conducted among the end users in the region. The energy and material flow modelling of the ground water system have been developed using Umberto NXT Universal and Ecoinvent dataset v3.0. The environmental impact assessment is carried out using well-known ReCiPe method. It is observed from the analysis that copper used in equipment of ground water supply system and energy consumption for ground water extraction generate significant impacts to the environment. The results thus obtained are very helpful in decision making and to formulate a suitable ground water development/withdrawal policy while dealing with different environmental issues of groundwater management.

Finally, Chapter-7 summarizes and concludes the research work after all the results and their in-depth analysis. The insights gained through the present study is believed to be of pivotal significance in identifying critical parameters. It would serve as a building block for taking decisions on identifying critical factors, which is lacking at present in the selected hyper-arid region.

Through the course of this study, an attempt has been made to formulate, develop and improve decision tool to assess suitability, potential zones, sustainability concerns and LCA of

groundwater supply system in hyper-arid region of Bikaner block in the state of Rajasthan, India. Several existing methods and approaches have been thoroughly investigated and analyzed before commencing the work on this study. Various issues related to selection of variables and cause-effects analysis have been analysed to get appropriate remedial measures through different models.