SUMMARY OF THESIS

A REMOTE SENSING & GIS BASED HYDRO-GEOMORPHIC APPROACH FOR IDENTIFICATION OF SITE SPECIFIC GROUNDWATER ARTIFICIAL RECHARGE TECHNIQUES A STUDY OF SAKAR AND SANG RIVER BASIN

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INTRODUCTION

Kutch district located in a crescent-shaped peninsula of Gujarat state of Western India is an arid region with water crisis and repetitive drought cycles. It is the largest district in Gujarat and has an area of 45,612 sq km constituting 23 per cent of the state. Kutch is like an island as it is bound by the sea in the South and West and by the Ranns (salt marshlands) in the East and North. Kutch was a princely state ruled by the Maharao of Kutch and was integrated into the state of Gujarat only in 1961. Kutch has 887 inhabited villages with a population of 1.2 million. It has ten Taluka or administrative sub-districts: Bhuj and Nakhatrana in the North; Lakhpat and Abrasa in the West; Mandvi, Mundra, Gandhidham and Anjar in the South and Bachau and Rapar in the East.

Kutch's geology, climate and topography are intriguing, making it a fascinating and challenging place to study water resources management. Legend has it, that much of Kutch was a navigable lake during the time of Alexander's conquest of Sind (Thakker: 1988).

Temperature fairly remains average in the district. Highest temperature goes up to 44.8 degree centigrade in summer and lowest temperature comes down to 3.7 degree centigrade in winter season. Rainfall is very low in Kutch district as low as 350 to 375 mm during the whole monsoon. Rainfall is erratic and variable.

The Kachchh peninsula is characterized mostly by ephemeral streams which carry water during monsoon only (Merh, 1995). The internal high land forms the main watershed with numerous streams draining the slopes in the radial pattern. Most of the rivers are of small length and having low sediment carrying capacity.

All of Kutch's 97 rivers are non-perennial and have a high run-off rate. It has therefore very low potential of surface and potable groundwater resources. However, overall resource

potential of the region, mainly coastal resources becomes one of the most added attractions and ideal regions for industrial development. Along with industrialization, population and basic infrastructure have also grown. This has resulted in manifold increase in industrial and domestic water demands and put groundwater resource of the region under tremendous stress. As the area is adjoining the seacoast, over exploitation of groundwater has also resulted in seawater intrusion in the aquifers thus, having considerable environmental implications. The Geomorphology of the Kutch district is just similar to “Reverse Bowl”. Hence, precipitated water immediately flows away by the rivers either in Rann or in Arabian Sea.

A decline in the groundwater causes crop failures, seawater intrusion in coastal aquifers; land subsidence etc. This problem is particularly observed in area between Sakar and Sang rivers of Kutch. More over the salinity add to this problem, as most of the dug wells in the area turn saline soon after their development.

Thus, there is an urgent need for artificial recharge of groundwater by augmenting the natural infiltration of precipitation into subsurface formation by some suitable method of recharge. For this, understanding of the hydro-geological framework and delineation of the fresh water zones is essential and important. In order to arrest the depletion in groundwater potential and to achieve sustainable development, several measures including artificial groundwater recharge can be suggested. In an effort to maintain the water table condition in balance, artificial recharge schemes are being implemented in various parts of the world. The selection of sites for artificial recharge is a very important task in recharge studies.

The present study will therefore focus on the selection of suitable artificial recharge structures based on hydro-geomorphic approach.

THE STUDY AREA: The study area comprises of Sakar & Sang river basin of Kutch. It comprises of ^{o} parts of Anjar Bhuj and Gandhidham Taluka occupying a total area of 324 .25

sq.km. Sang river originates from near Gandher village, of Bhuj Taluka while Sakar originates near Vidi, in Anjar Taluka. Both the rivers are east flowing and disappear into Gulf of Kutch near the mouth of little Rann. The basin lies between 22°59' and 23°11' N latitude 69°47' and 70°13' east longitudes.

OBJECTIVE AND SCOPE

The study aims at carrying out an in-depth study on hydro-geomorphic approach for identification of site specific groundwater artificial recharge techniques in Sakar and Sang river basin. The precise objects of the study are as follows:

1. To understand the hydro geological framework.
2. To delineate fresh water and brackish water aquifers in the study area.
3. To suggest areas favourable for recharge by integrating various themes with different recharge possibilities and to recommend suitable recharge structures.
4. Preparation of guidance manual for rapid reconnaissance of groundwater resources in arid and semi-arid environments.

DATA SET AND METHODOLOGY

PRIMARY DATA CAPTURE

Extensive field work was done for the collection of the data related to water resources. Data related to various parameters like Groundwater level, Groundwater Quality, Soils, Geology, Socio-economics, Pump test, resistivity survey, Geophysical Subsurface Logging etc. was collected from the field survey.

SECONDARY DATA CAPTURE

A detail regarding various other data which cannot be generated from the field was collected from various private agencies, NGOs and government agencies.

Geological and Geomorphological maps: were collected from GSI and Kutch Development Plan. Their field verification was done and data regarding the lineaments was generated from the satellite images as well.

Meteorological data were collected from Data centre, Gandhinagar while the rainfall images were downloaded from the GSDMA website.

Soil maps were collected from (NBSS) National Bureau of Soil science while their other properties were studied from the field sample.

Groundwater Quality, water level and other related data was obtained from various government agencies like GWSSB, CGWB, District lab-Bhuj,

Elevation data is obtained from satellite images of ASTER and updated with the data collected from the field survey wherever required.

Land use maps are generated from the combination of satellite images of Landsat 8, LISS IV, and Google earth (Digital Globe). Landsat 8 images were obtained from the site of USGS This images are very useful for the interpretation of Large features or the features or events that cover larger part of the images like Agriculture fields, Fallow lands, Rocky terrain, waste lands etc. while the finer objects or features like small water bodies, roads, settlements, industries etc. which require high resolution satellite images downloaded from Google earth i.e. digital globe and Geoeye.

Software used are ARC GIS version10.1, IBM SPSS Statistics 22, Aquaveo GMS, GPS Trimble YUMA 2 and Garmin eTrex.

APPROACH AND METHODOLOGY

To achieve the above cited objectives a multi - disciplinary approach has been adopted. The envisaged methodology has dealt with following aspects

Phase I:

This phase deals with the collection of the data from various sources, its geometric correction and field verification for the accuracy and validation. Literature survey from libraries of The Maharaja Sayajirao University, Kutch University, online journals and articles are accessed. Secondary data from several sources like Census of India, Survey of India, Planning Atlas, Geology and Soil Survey maps , District Laboratory Bhuj, GWRCD, Data Centre ,Central Ground Water Commission Reports, Ground Year Books, Statistical and Economic Abstract Of Gujarat, Agriculture Census ,discussion with officers at Kutch and Personal observation.

Phase II: Deals with the delineation of hydro geomorphic units considering parameters influencing the hydro geological properties. It consists of creation of thematic layers of Hydrology like Drainage, water bodies, canals, irrigated areas, well data and rainfall data. Lithology, geomorphology, Land use/land cover, Slope and Aspect Maps along with base map details based on the visual interpretation of satellite data in conjunction with field data and existing secondary data are also generated.

Fieldwork: Participatory survey for well inventory, Sampling and on-site analysis, pump test, infiltration test and ground checks of satellite image analysis.

Phase 3: Deals with spatial data integration and its analysis. It consists of a) estimation of ground water prospects by taking into account the well observatory data, b) Probable sources of pollution and c) identification of suitable locations for constructing recharge structures.

Outcome

The study will help in understanding the following:

1. Identification of sites with specific groundwater exploration potential and selection of suitable structures for improving the groundwater regime of the area.
2. Identification of possible pollutions and sources.
3. Predict the trend of groundwater in the future.
4. Hydro geological framework of the area and delineation fresh and saline water areas.
5. Guidance manual for rapid reconnaissance of groundwater resources in arid and semi-arid environments.

FINDINGS: Summering the conclusion

- Having regard to the conditions of rainfall, the nature of the soils and the geological formations, which prevail in Kutch, reliance cannot be placed upon the surface storage for an adequate or satisfactory water supply for the town of Gandhidham.
- Storage reservoirs should however be constructed as a measure of conservation of the water resources of Kutch. These reservoirs will impound run-off from the surface, which would otherwise flow, to the sea or the Rann. Water so impounded will be put to maximum use in such a manner that evaporation losses would be kept to a minimum while percolation water will replenish supplies available in the underground water.
- Ground resources of study area have not been intensively developed for other purposes like agriculture with the result that adequate quantities of water will be regularly available from the source to maintain population. Though good amount of water is being used for the drinking purpose from the dug wells.

- There is depletion in the water level within the study area even when there is a normal rainfall or a surplus rainfall for few years. The reason for this can be understood by the daily rainfall patterns studies. From the data collected it was observed that the most of the rain in study area occurs only with in few days of the total monsoon seasons. Hence there are more chances of rainfall runoff rather than a recharge if this rain water is not properly managed. The requirement for the groundwater recharge can be clearly understood from the analysis.

- The SCS-model analysis in the study area based on Hydro-Geological parameters supports in proving that urban development has also contributed to increase in the runoff while acting as a barrier between the surface and the subsurface aquifers lowering the groundwater tables.
    - In the last few decades, Anjar, Bhuj and Gandhidham Taluka have experienced an increase in urban area while reducing the overall agriculture land. Due to this rapid expansion and ignorance of Humans to tackle the future groundwater problems has affected the local water environment. Increased pollution in Water is another problem that can be considered as a by-product of this urbanization process.
    - It can be predicted that if proper recharge structures are implemented along with well thought-out water management plans for the current usages, there are high chances of revival of the water level in catchment area of Sakar and Sang river basin (study area). According to the model considered for coming 20 years, around 25-40 mtr rise in the water level can be expected. The major positive impacts are mostly in the Taluka of Anjar followed by Bhuj and lastly Gandhidham. Owing to the proximity to the coast, no major changes visible near the coastal part of Gandhidham taluka.
    - The DRASTIC analysis shows higher risk areas mostly in the southern part of the study area with some dispersed moderate to high risk areas throughout the study area.

Few of the area in the southern portion of the Gandhidham Taluka are in the high risk as shown in the map in red colour where there are agriculture fields. This area is also adjacent to the major water body of Anjar Taluka. A little portion on North and some region of the south of Anjar Taluka fall in moderate risk, whereas the upper areas near Bhuj and few portion towards the north in the Anjar Taluka area at comparatively lower to moderate risk.

- In this particular application it is to be noted that the area is a coastal zone and hence sea water ingression cannot be avoided due to the presence of various industries at the coast as well as Kandla port and also due to over exploitation of the groundwater resources due to the rising demand. Sea water ingression is also to be considered here as an additional factor.
- The study and analysis of the integrated data facilitates evaluation of the unit in terms of the potential of the aquifer material for the occurrence and movement of groundwater, amount of the water available for recharge and the actual recharge taken place. The main sources of recharge to the aquifer/hydro-geomorphic unit are rainfall, water bodies, return flow from the irrigation, etc. The amount of water available has been taken in to account for assessing the recharge condition from all these sources. However, the total available water may not percolate in to the ground. It depends on the infiltration capacity of the soil and the hydrogeological properties of the underlying rock formations. Hence, the actual recharge is assessed not only based on the water available from different sources but also the hydro-geological properties of geological material. Overall, the locations for recharge structures are identified on upstream of the problematic area. They are located mainly on 1st to 3rd order streams and at the most up to the initial stages of 4th order stream. No recharge structure is located on major streams / rivers occupying large area.

FUTURE SCOPE

Field investigation is inevitable before implementing any water-harvesting program. Further, the groundwater resource estimation has to be taken up at the regular intervals to know the net balance available for future use.