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WATER RESOURCE MANAGEMENT USING GEOSPATIAL TECHNOLOGY: A REVIEW WITH REFERENCE TO GROUNDWATER

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Abstract : *The objective of this paper is to demonstrate the capability of Remote Sensing (RS) and Geographic Information System (GIS) in water resource management for gauged as well as ungauged watershed. Availability of fresh water determines the development of any region or country because water plays a crucial role for the overall development. Groundwater is a vital natural resources which plays an important role for the development of rural as well as urban areas. Groundwater has limited extent and volume. The tremendous increase in the demand of groundwater for the purpose of household, agricultural and industrial use leads to the concept of water resource management. The result of over exploitation of groundwater throughout the world include lowering of water table, resulting lower agricultural productivity, sea water intrusion in coastal aquifer, land subsidence, groundwater quality degradation, droughts etc. To protect this precious resource from over exploitation and pollution, it is important to implement artificial groundwater recharge systems such as farm ponds, check dams, percolation tank and nala bund etc. To maintain the daily needs and uses of water and to produce sustainable water supply to the livelihood or to start and continue the production of any industrial set up in that zone.*

Keywords - *Remote Sensing, GIS, watershed, groundwater*

1. INTRODUCTION

A minority of geologist and other geoscientists have been using computers for manipulation of spatial data since the 1960. Remote sensing can be defined as the observation of targets from distance without physical contact (Peiffer, 2007). GIS is a computer based system dealing with the geographic data or maps for capturing and processing spatial data of geographic nature and used in input, storage, manipulation and display of geographic data (Sharma et. al, 2015). Availability of freshwater has determined the growth of civilization in the past. As the world's population continues to increase, it is predicted that the availability of fresh water for human needs is a serious limiting factor in the future. Though the estimated water volume on the planet is about 1.4billion km^{3}nearly 96.5% of it is held up in the ocean as saltwater. An estimated 10.5million km^3 of freshwater, which is a third of total freshwater available on earth are stored below the surface in the form of groundwater. It is widely, but unevenly distributed and is an important source for irrigation and drinking purposes. Groundwater normally exists whenever water infiltrates beneath the surface, the soils and rocks beneath the surface are porous and permeable enough to hold and transmit this water and the rate of infiltration is sufficient that these rocks are saturated to an appropriate thickness. Groundwater is a renewable source and therefore, if located, exploited and managed carefully, can sustain forever (Handbook R.S., 2016). Watershed deterioration takes place due to uncontrolled, unplanned and unscientific land use aided by human inventions. Watershed management is simply watershed "protection". It aims to utilize land and water resources wisely, to enable optimum and sustainable production, reduce floods with minimum hazards to natural resources. It essentially relates to the practice of soil and water conservation in the watershed. Now a days, there are a large number of satellites used for observing the earth and atmospheric features. According to the purpose of their use satellite system is divided into two groups earth resource satellite and environmental satellite. Earth resource satellite provide the information of same area relatively infrequently (days) with relatively high resolution e.g. Landsat (Land Satellite) (USA), IRS (Indian Remote Sensing) (India), OKEAN (Russia), SPOT (Satellite Positioning and Tracking) (France), ERS (*European Remote Sensing*) (ESA and Canada), JERS and ADEOS (Japan), RADARSAT (Canada), CBERS (*China Brazil Earth Resources Satellite*) (China).Environmental satellite provide the information of same area relatively frequently (hours) with relatively low resolution e.g. NOAA (*National Oceanic and Atmospheric*), INSAT (Indian National Satellite System) (India), GOES (*Geostationary Operational Environmental Satellite*) (USA), GMS (*Geostationary Meterological Satellite*) (Japan) (Jensen, 2000). There are lots of studies carried out on the selection of artificial recharge sites by using remote sensing and GIS. Rajat et al,2013 evaluated the artificial recharge sites of Loni watershed in the Unnao and Rae Bareli districts of Uttar Pradesh, India.He used Landsat ETM+ path-144 and row-42 of image and

Digital Elevation Model (DEM) derived from ASTER image. In his study, SCS-CN hydrological model has been used that requires slope, land use/land cover map, HSG and rainfall data and morphological parameter. He concluded that the Loni watershed was having water scarcity. Srivastava et al. (2009) Mayurakshi watershed, lying in Dumka and Deogarh districts of Jharkhand state was considered as the case study area. They used Indian Remote Sensing satellite (IRS-1C), Linear Imaging Self Scanner (LISS-III), sensor of path-107 and row-55 acquired on 4th March 2002 in four spectral bands. The analysis was done using ERDAS IMAGINE-8.4 digital image processing software. In this study, a set of Boolean logic was developed for evaluating the suitability for each of the area specific categories. Mayilvaganan et. al (2011) in their research tried to delineate ground water potential zone using geospatial techniques. The thematic layers used for this study were-lithology, geomorphology, drainage density, soil, lineament, land use and surface water body. These layers were prepared using the IRS-P6 LISS III satellite imagery and conventional data. Beside this soil and drainage maps were digitized from published maps. These thematic layers were integrated using ArcGIS V 9.2 software to get the Ground Water Potential Zonation map of the study area. The GIS based output result was validated using water level depth data collected from Institute Of Water Studies, PWD and lastly it was concluded that the RS and GIS technique are very efficient and useful for the identification of Ground Water Potential Zone. Singh et. al (2009) tried to access Ground Water Potential Zones by using GIS technique with the help of ArcGIS software. The thematic layers created for this purpose are- geology, geo-morphology, hydrological soil group, drainage map and land use/land cover map. These layers are overlaid to get the final out put map. The GIS based output result was validated by conducting field survey of various wells in the study area. Rao et al. (Oct, 2009) in their study of selection of ground water potential zone, coupled hydro-geomorphologic mapping with hydrogeological investigations. Thematic layers of drainage, geology, geomorphology, lineaments and well inventory are prepared by using toposheet, GSI geology map & digital data from IRS-ID,LISS III (April 2004).Ten hydrogeomorphic units are delineated on satellite data out of which five were found as recharge zones and five were found as runoff zones. A buffer zone was created in lineament map to establish its influence on ground water occurrence and distribution. The ground water potential zones were identified through GIS analysis and it was classified into five categories from very low to high. Hammouri N et al. (Aug, 2012) used integrated approach to groundwater exploration using RS & GIS technique. This method is based on the evaluation of a set of hydrological, geological and topographical parameters that influence the occurrence of Ground Water. The following thematic maps were prepared- lineament density, drainage density, slope-steepness, topographical elevation and geological formation. Lastly the thematic maps were over laid after giving suitable weightages and scores to each and the Ground Water Potential Zone was found. Waikar M.L and P. Nilawar Aditya (2014) in their research to identify ground water potential zones using RS & GIS technique created the following layers – geology, slope, drainage density, geomorphic units and lineament density. These layers were created using the satellite data and Survey of India toposheet of scale 1:50000. It is then integrated with weighted overlay in ArcGIS. Suitable ranks were assigned for each category of these parameters. For these geographic units weight parameters were decided based on their capability to store ground water. The procedure is repeated for all the other layers and resultant layers were classified again. The ground water potential zones were classified into five categories – very poor, poor, moderate, good and excellent. Bera Kartick et al. (2014) in their Ground Water Potential Work used RS & GIS technique & the following thematic maps were prepared:-drainage density, land use/land cover, soil, rainfall, slope steepness, geology & geomorphology. IRS 1D LISS III satellite data of 4th February,2008 along with other data sets, existing maps and field observation data have been used to extract information on the hydro geomorphic features of the study area. All these thematic maps were changed into raster format and superimposed by weighted overlay method for Ground Water Potential Zoning. Bhunia et al. (2012) conducted their research on assessment of Ground Water Potential Zone based on multi-criteria evaluation approach. For this purpose seasonal land use/ land cover, hydro-geology, geo-morphology, soil, drainage density, pre monsoon and post monsoon water level and elevation layers were generated. A probability weightage index overlay method was adopted. It was based on Bayesian statistics. These capability values were then multiplied with the respective probability weightage of every thematic layers. B.Dixon in his paper , incorporate GIS, GPS, remote sensing and the fuzzy rule-based model to generate groundwater sensitivity maps and compare the results of new methodologies with the modified DRASTIC Index (DI) and field water quality data.

2. VARIOUS METHODOLOGY FOR GROUNDWATER POTENTIAL ZONATION

2.1 Analytic Hierarchy Process (AHP)

AHP is one of the best multi criteria decision making methods that was originally developed by Prof. Thomas L. Satty in 1980.In short, it is a method to derive ratio scales from paired comparisons. The input can be obtained from actual measurement such as price, weight, etc. or from subjective opinion such as satisfactory feelings and preference.The AHP procedure had been applied for Decision Support System (DSS) including data mining and machine learning and so many applications.

2.2 Fuzzy Logic

In 1965, Zadeh proposed the concept of fuzzy logic. According to zadeh, which states that a complex system will be better represented by descriptive variable of linguistic types than by the traditional representation of differential equations (Cox, 1994). Basically in classical set theory, the membership of a set is defined as true or false, 1 or 0.

2.3 Frequency Ratio Model

According to Bonham-Carter (1994), the frequency ratio is the probability of occurrence of a certain attribute. Frequency ratio approach is based on the observed relationships between distribution of groundwater qanat locations and each groundwater related factor, to reveal the correlation between groundwater qanat locations and the factors in the study area (Seyed et. al, 2015). Samy et. al in his study used frequency ratio model in three steps : the construction of data base,the calculation of weight and data integration and verification procedure obtained from previous studies.

2.4 Shannon's Entropy Model

According to Theil in 1972, entropy index as a measure of the average difference between a unit's group proportions and that of the system as whole (Seyed et. al, 2015). There is a one to one relationship between the quantity of entropy of a system and the degree of disorder called Boltzman principle and has been used to represent the thermodynamic status of system (Yufeng, 2009).

2.5 Boolean Logic

This method may be the simplest and best-known type of GIS model is based on Boolean operations. In effect, Boolean modelling involves the logical combination of binary maps resulting from the application of conditional operators (Bonham-Carter, 1996). The various layers of evidence are combined to support a hypothesis, or proposition. Only one or zero values are assigned to each unit area, specifying whether it is satisfactory or unsatisfactory, respectively (Ghayoumian, 2007).

3. CONLUSION

Groundwater is a vital natural resources which plays an important role for the development of rural as well as urban areas. Groundwater has limited extent and volume. The tremendous increase in the demand of groundwater for the purpose of household, agricultural and industrial use leads to the concept of water resource management. Geospatial techniques permit rapid and cost effective natural resource survey and management. There are lots of research going on the water resource management. Based on the observer and expertise different people use different methods for the calculation of ground water potential zonation. From literature review it is concluded that based on the availability and feasibility of data they predict the potential zone.

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