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Remote Sensing and GIS approaches in Artificial Recharge of the Ground Water Potential Zones in PT-7 Watershed of Akola District Maharashtra

Khadri S.F.R.[1], Kanak Moharir[2]
[1,2]*Department of Geology, Sant Badge Baba Amravati University, Amravati-444602 (MS)*

ABSTRACT: *The importance of water is felt in all sectors as the demand and needs of the populace is growing. The remotely sensed data provides synoptic viewing and repetitive coverage for thematic mapping of natural resources. In the present study hydrogeomorphological, soil, lineament and geomorphological mapping has been carried out in PT-7 watershed in Akola District, Maharashtra , The area is demarcated from the survey of India Topographical maps were used, it covers an area about 93.66sq.km. In this paper LISS III Satellite Image data in conjunction with Survey of India Toposheet (1:50000 scale) and field inputs data were used for thematic mapping. Geomorphic units identified through visual interpretation of FCC include: alluvial plain, plateau, pediment pediplain, linement, and land use land cover. In addition, lineaments were mapped since they act as conduit for groundwater recharge. The application of the increasingly and internationally accepted method of artificial recharge on the ground water aquifer was decided to be the most effective for the restoration of balance of the hydrogeological system. Scenes contour is digitized for preparing elevation map and drainage pattern analysis. Amount of rainfall, soil type and water level of the well were some important data points which are collected and estimated during the field study. They were key parameters for identifying groundwater prospective zones. Digital as well as visual interpretation techniques were applied for creating geological map, lineament map, and land use/land cover map and also creating DEM, and TIN. Groundwater elevation models were created through spatial interpolation method to analyze groundwater flow direction, groundwater flow accumulation and groundwater contour. All these thematic layers were analyses after converting them into overlay. The GIS technology provided suitable alternative for efficient management of large and complex database to study groundwater resource and design suitable exploration plan of artificial recharge zone. Use of state-of-the-art technology and estimation of all the parameters involved, which are necessary, have been taken into account. Keeping this as an objective, to identify the suitable sites for artificial recharge zones an integrated approach of remote sensing and GIS approach techniques were used.*

Keywords: *Remote sensing, GIS, Watershed, Hydrogeomorphological mapping, Groundwater potential zones, Satellite LISS-III Data, Water Level Map.*

I. INTRODUCTION

Remote sensing and GIS are playing a rapidly increasing role in the field of hydrology and water resources development. Remote sensing provides multi-spectral, multi-temporal and multi-sensor data of the earth's surface (Choudhury, 1999). One of the greatest advantages of using remote sensing data for hydrological investigations and monitoring is its ability to generate information in spatial and temporal domain, which is very crucial for successful analysis, prediction and validation (Saraf, 1999) However, the use of remote sensing technology involves large amount of spatial data management and requires an efficient system to handle such data. The GIS technology provides suitable alternatives for efficient management of large and complex databases. Information from satellites is becoming more and more important for environmental research. An important part of this information concerns water an element most essential for man, its phases and peculiarities. In general, water resources in India are very unevenly distributed both spatially and temporally. Idiosyncrasy of monsoon and diverse physiographic conditions give rise to unequal distribution of water. Over the years, increasing population, urbanization and expansion in agriculture and domestic water utilization has accentuated the situation. The present study is aimed to understand some of the crucial problems of groundwater quality and management with the help of latest available techniques in an integrated manner. The proposed study will certainly fill the crucial gap of knowledge related to the salinity problem by providing detailed field and laboratory data with GIS analysis for proper interpretation. According to conserve to next generation people to consider going the present work is an attempt towards this direction. The study focuses on development of remote sensing and GIS based analysis and methodology in groundwater recharge studies in watershed. In order to demonstrate the Role of remote sensing and GIS based methodology, the sub-watershed of PT-7 of Akola district state of Maharashtra (India) has been taken for analyzed.

Study Area

The present study area is sub watershed of Purna river lies between 20°51'0"N and 21°14'30"N latitude and between 76°46'0"E and 77°3'0"E longitude covered Akola district of Maharashtra. The basin area is demarcated from the survey of India Topographical maps were used, it covers an area about 564.55sq.km (fig 1). The sub watershed area is represented by the survey of India Topographical maps; 55D/13, and 55C/16 was used.(Fig.1)

II. AIM AND OBJECTIVES

The basic aim of present study is to conduct the remote sensing and GIS technology in order to identify the suitable sites for artificial recharge zones with an integrated approach of remote sensing and GIS approach techniques which are being followed by these objectives.

To use of remote sensing and GIS technique in groundwater recharge investigations in sub watershed.

To prepared the groundwater potential zones in the sub watershed.

To identify the interrelationships of recharge areas with geology, geomorphology, soils and structure of the sub watershed.

To suggest suitable sites and methods for artificial recharge to augment groundwater recharge with Village Tank, cement nala bund etc. in the sub watershed.

III. METHODOLOGY

The methodology adopted in the present study is presented schematically in figure 5 and described in the following steps: The LISS-III Open Source satellite image was used for linear, aerial for drainage basin analysis and interpretation (Fig.2). The image interpretation characteristics such as tone, texture, shape, size, pattern and association along with sufficient ground truth and local knowledge were used to finalize the maps of the PT-7 watershed area. The maps were georeferenced and digitized using the Arc GIS 10 and attributes were assigned to create the digital database. The slope map is generated using SRTM data and spatial analyst tool used from Arc Map software 10.00. The Survey of India toposheets of scale 1: 50,000 are used for delineating the watershed boundary, drainage pattern for the preparation of base map and extracting different thematic layers for the various part of analysis namely drainage, road and water bodies etc. Geomorphology map is prepared using visual interpretation technique and interpretation keys such as tone, texture, size, shape, pattern, shadow and association. The land use/cover categories will be visually interpreted into line maps; the mapped categories may vary from map sheet to map sheet depending on ground conditions. Land Use/Land Cover analysis is carried out with the help of LISS III open source satellite image. The supervised, unsupervised classification techniques and ground truth verification method used for the preparation of land use/ land cover map. Various features are identified and distinguished using interpretation key and visual interpretation technique. The fourth stage involves the integrated analysis of multi-disciplinary data sets to construct composite information set to explain various queries in the spatial context. GIS and land use are natural partners as both of them deal with spatial data. The land use evaluation with respect to groundwater changes is provided.

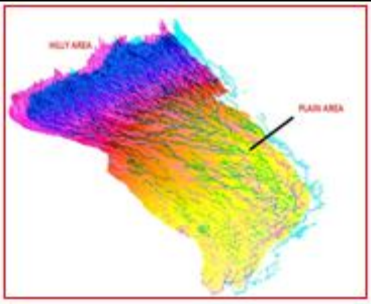

Fig. 2 3D Model View of PT-7 Watershed

The study area can be broadly divided into low lying plain towards the banks of the PT-7 Sub-watershed in the northeast and horizontal Deccan Trap flows with multiple scarps and abrupt cliffs towards the southern parts. The study area consists of various erosional surfaces in step-like terraces. The horizontal dispositions of the lava flows with a fair degree of uniformity in lithology have considerably simplified the changes brought by the secondary processes like weathering and denudation.(Fig.2) .

Rainfall

The area receives major part of the rainfall (about 45%) during South-West-monsoon period there are eleven rain gauge stations in the area which have rainfall recorded for more than 50 years. The normal rainfall for Akola is 800 – 100 mm. (source IMD). It is minimum in the North-Western part of the district and increases towards the South Eastern parts of the district i.e. toward Washim district.

Geomorphology

Geomorphology is the study of the shape or configuration of the earth's solid surface above and below ocean level and it involve the classification of landforms and the processes by which they develop. In other words, geomorphology is the study of landforms and landscapes, including the description, classification, origin development and history of planetary surfaces. In this present study has interpreted landforms such as alluvial plain, water body, piedmont zone, plateau, structural hills and habitation mask. The geomorphological map of the PT-7 sub-watershed has prepared by visual interpretation of the LISS-III satellite image and visual interpretation is carried out base on the image characteristics like tone, size, shape, pattern, texture, location, associated background etc. in conjunction with existing maps and literature.)(Fig.4).

Soil Characteristics of the watershed

Soil is important upper layer of the earth surface to support crop and vegetation for the economic development and food requirement of the human. The soil information for the study area was digitized from the soil map. Generally, seven (7) types of soil had been identified in the study area. At the lower area of watershed consists of clayey soil. The soil types of study area are clayey soil, clay loam, clayey, gravely clay, gravely clay loam, gravely sandy loam, sandy clay, and gravely sandy clay. The erosion of the top soil decreases the productivity of land and leads to failure of crops. (Fig .6). Since soil spectral reflectance can be rapidly and easily obtained with high repeatability, numerous samples can be studied to establish trends of change in soil hydraulic properties in a watershed. In order to spatially extrapolate the soil physical condition in the watershed, the spectrally defined physical condition indices were calibrated to pixel reflectance extracted from the IRS image of the study area. However, the conditional dependency model was developed to remove potential errors in the calibration model due to correlation between factors. Figure 4 below shows the graphical illustration for the conditional dependency model. There was significance relationship between soil physical condition indices and reflectance values from band 3, band 5 and band 7 (at 5 % significance level)(Fig.3).

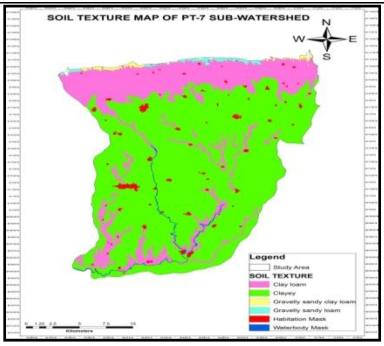

Fig.3 Soil Texture Map

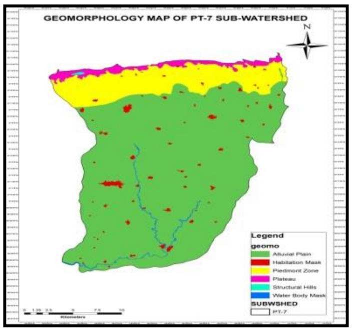

Fig.4 Geomorphology Map

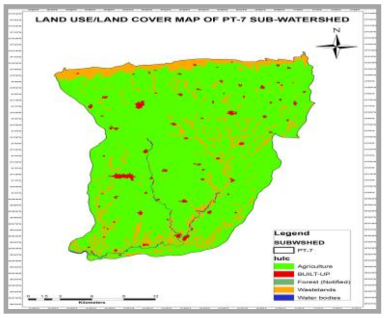

Fig. 5 Land Use/Land Cover Map

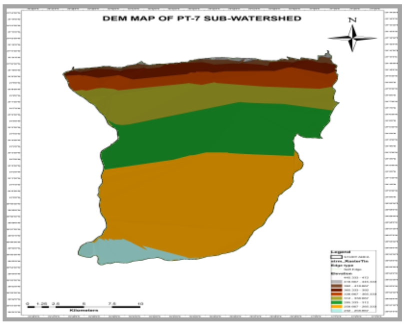

Fig.6 Digital Elevation Model Map

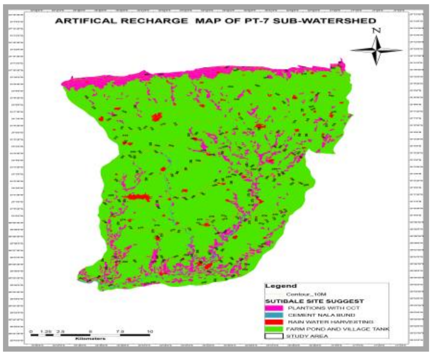

Fig.7 Artificial Recharge Map

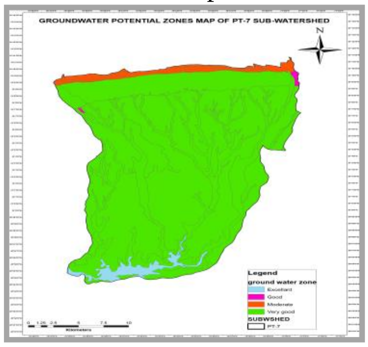

Fig.8 Ground Water Potential Zones Map

Land use/land cover

The land use of the study area is characterized by a mixture of forest cover, agricultural activities and wasteland besides water body and river sediment (Saraf, 1999). These are readily interpretable from the satellite images. The western part of the watershed has very little forest cover as compared to the northern part. The most of the land is under agricultural crop land in the present study area and other area is covered by forest, built up, waste land, and Water body. Land use describes how a parcel of land is used such as for agriculture, settlements or industry, whereas land cover refers to the material such as vegetation, rocks or water bodies that are present on the earth surface. The water bodies include river, canal, tank, pond and reservoir. (Fig.5).

Artificial recharge site selection

Artificial recharge is the process of augmenting the natural movement of surface water into underground formations by some artificial methods. This is accomplished by constructing infiltration facilities or by inducing recharge from surface water bodies. In hard rock areas, the underlying lithological units do not have sufficient porosity and permeability. In these areas, groundwater recharge falls short of the water that is being taken out of the aquifers. Hence, groundwater cannot suffice the requirement for agriculture or drinking water. Thus, additional recharge by artificial methods becomes necessary to meet the water deficit. In India, artificial recharge measures are taken in the watershed development. The performance of these efforts can be immensely increased if they are performed through proper scientific planning. Integrated remote sensing and GIS can be a very powerful tool for planning of suitability for artificial recharge structures. However, this powerful tool has not attained wide applications for this purpose till now in India. In this present study has successfully demonstrated an integrated remote sensing and GIS technique to suggest suitable area for future artificial recharge structures in the PT-7 watershed .The site selection is purely based on hydro geological point of view, the engineering aspects are not considered here. (Fig.6)(Fig.7).

Selection of Artificial Recharge Site

A remote sensing and GIS based method is found to be very useful in suitability analysis for artificial recharge sites in the sub watershed. For such analysis the first task was to identify the factors facilitating recharge to take place. The existing artificial recharge system in the area has been studied with respect to its hydro geomorphology, topography and response in the water level of the wells. Based on these observations, a set of rules has been designed to demarcate the most suitable site and also to find out the exact sites for artificial recharge. The following thematic information layers are used in this suitability analysis and weighted indexed overlay model has been applied: (a) Geology,(b) Geomorphology,(c) Soils,(d) Slope.

Groundwater Resource Assessment

Quantitative assessment of groundwater recharge is an important issue in groundwater development. Estimation of groundwater recharge requires proper understanding of the recharge and discharge process and their interrelationship with geological, geomorphologic, soil, land use and climatic factors. There are various methods in use for the quantitative evaluation of groundwater recharge e.g. (a) groundwater level map(b) rainfall infiltration method. In the present study, the groundwater level map and ground water potential map is used for the quantitative estimate of groundwater recharge in the PT-7 watershed. The Role of Remote Sensing and GIS in Artificial Recharge of the Ground Water Aquifer in the PT-7 Sub Watershed in the Purna River Basin, Akola District, Maharashtra. A conventional approach for groundwater recharge assessment has some limitations in spite of its simplicity and wide applicability in varied hydrogeological setup. Groundwater movement is controlled by natural boundaries; watershed is the most appropriate unit for groundwater recharge estimation through constructs the cement nala bund, village tank and percolation ponds the spatial variability in the components of recharge is not considered. In case of remote sensing and GIS based method. (Fig.8).

Spatial distributions of the variables are taken into account, thus preparing an information layer for the whole of a watershed. Further, remote sensing data provides most accurate information of the ground, thus minimizing fieldwork. Seasonal information is required for estimation of recharge.(Fig.9).

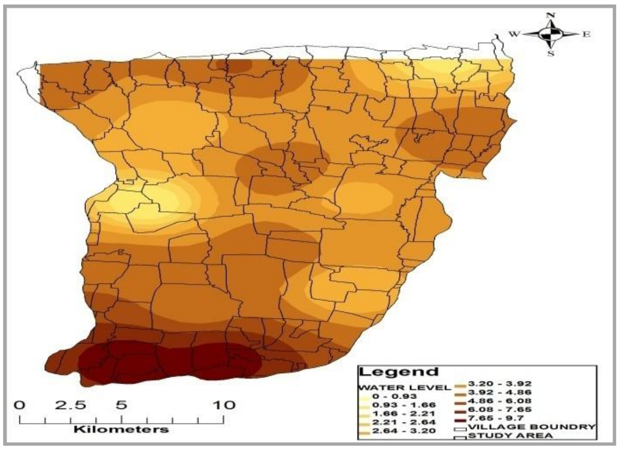

Fig.9 Water Level Map Of Pt-7watershed

IV. CONCLUSIONS

Groundwater is a precious resource of finite extent. Over the years, increasing population, urbanization and expansion in agriculture has lead to the unscientific exploitation of groundwater creating a water stress condition. This alarming situation calls for a cost and time-effective technique for proper evaluation of groundwater resources and management planning. Groundwater development program needs a large volume of data from various sources. As demonstrated successfully in this study that the integrated remote sensing and GIS can provide the appropriate platform for convergent analysis of large volume of multi-disciplinary data and decision making for groundwater studies. The groundwater prospect map is a systematic effort and has been prepared considering major controlling factors, which influence the water yield, artificial recharge site and quality of ground water. The maps which are essential as basis for planning and execution of groundwater exploration have been computed in this study.

The following conclusions are drawn from the above study:

In the present study a Role of remote sensing and GIS based methodology has been developed and demonstrated for evaluation of groundwater resources.

The present study has demonstrated that the recharge sites situated on a gentle slope and lower order streams are likely to provide artificial recharge to a larger area.

Combination of geology, land use land cover, geomorphology, contour, soil and digital elevation model has been found very useful in the selection of suitable sites for artificial recharge.

Change in land use is mainly due to the hydrological factors as is clear from the change image derived by subtraction of the land use maps.

Moderately high-resolution satellite images data (LISS-III) provide details of the terrain, as well as a synoptic overview, to visualize the general groundwater condition indirectly.

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