International Journal of Research (IJR)
e-ISSN: 2348-6848, p- ISSN: 2348-795X Volume 2, Issue 10, October 2015
Available at http://internationaljournalofresearch.org

Identification of Artificial recharge zone of the selected watershed using Remote Sensing and GIS

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Abstract

Artificial recharge is the most powerful management tool to assure sustainability of ground water resources. In the present scenario of our world's burgeoning population which is becoming increasingly difficult, it must rather than a challenge for any country to meet the task of providing sufficient quantity of water to each and every person in the face of the changing consumption patterns, impacts of the climate change and degradation of the finite land and water resources.Artificial groundwater recharge is becoming increasingly necessary as growing population require more water and as more stores is needed to save water in times of surplus for use in time of shortage. The remotely sensed data provides synoptic viewing and repetitive coverage for thematic mapping of natural resources.In the present study land use and land cover, soil, and geomorphological mapping has been carried out in study area.

The intersection zones of lineaments provide potential for ground water accumulation and ground water recharge. Occurrence of groundwater in such rocks is essentially confined to fractured and weathered zones. The present paper aims to establish basic information for site selection of artificial recharge structures to the aquifer systems by preparing various thematic maps such as geology, geomorphology, Land use/ Land cover etc.which have been prepared on visual interpretation techniques using the remote sensing data with the help of GIS techniquesand topographic information along with secondary informationand limited field checks of the study area, that falls in and around the study area. Geomorphic units identified through visual interpretation of FCC include: alluvial plain, plateau, pediment, Pediplain, and land use land cover.Groundwater elevation models were created through spatial interpolation method to analyze groundwater flow direction, groundwater flow accumulation and groundwater contour. 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.

Keywords: Artificial Recharge sites; GIS; Groundwater potential zones; Remote Sensing and GIS

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). In the recent years, many studies concentrated on application of remote sensing and GIS for artificial recharge (Sharma 1992; Anbazhagan 1994, unpublished PhD thesis; Ramasamy and Anbazhagan2005, Anbazhagan and Ramasamy 2001).However, the importance of artificial recharge was realized in India only about four decades ago.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

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successful analysis, prediction and validation (Saraf, 1998) However, the use of remote sensing technology involves large amount of spatial data management and requires an efficient system to handle such data. GIS is an effective tool to analyze spatial and non-spatial data on drainage, geology, landforms parameters to understand their interrelationship. The concept of integrated remote sensing and GIS has proved to be an indispensable tool in integrating urban planning and groundwater studies.

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 watershed of Man river basin of Akola and Buldhana district state of Maharashtra (India) has been taken for analysed.

Study area

The Man river basin is situated in Akola and Buldhana Districts, Maharashtra which is located between 20°54′ 59” N latitude and 76° 41’23’’ E longitude. The study area is covered by Survey of India toposheets55D/7, 55D/9, 55D/11, 55D/13, 55D/14 and 55D/15 on 1:50,000 scale. The study area is occupied by alluvium and Deccan basaltswhich are horizontally disposed and is traversed by well-developedsets of joints. (Fig.1)

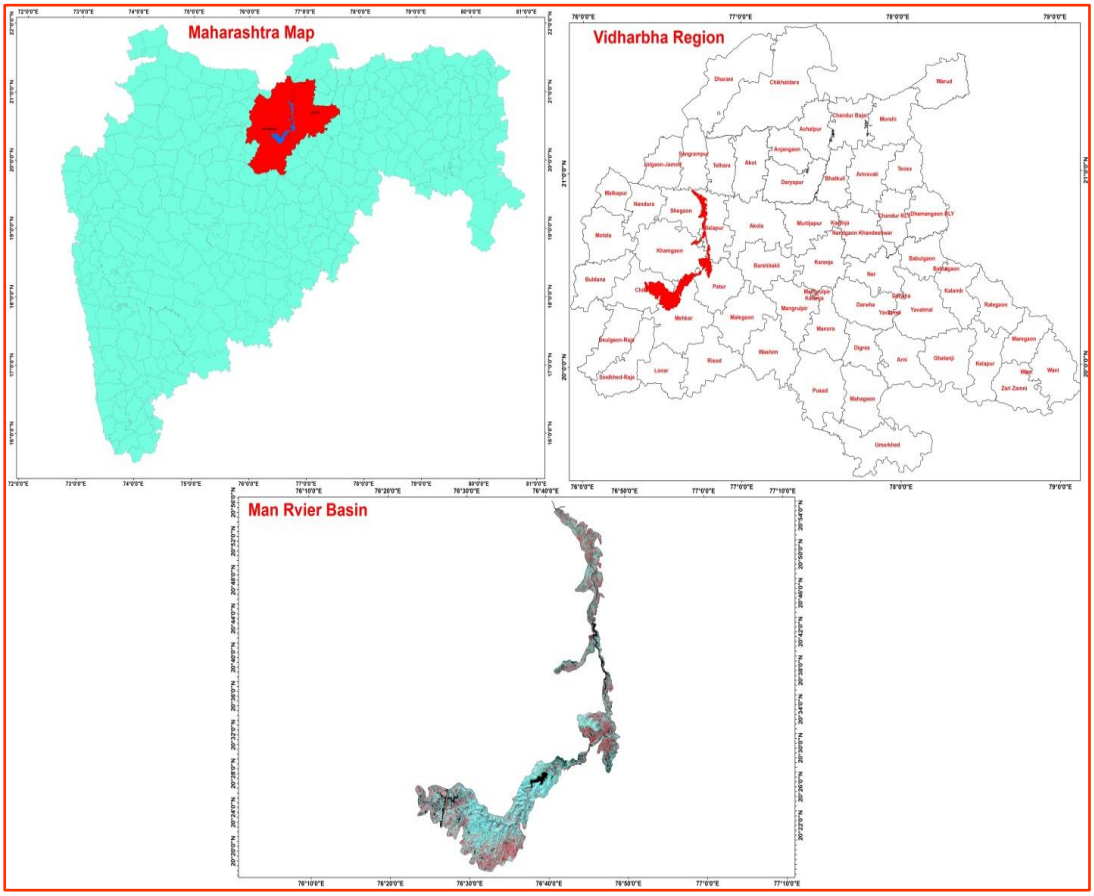

Fig. 1Location Map of Man River Basin.

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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.

1. To use of remote sensing and GIS technique in groundwater recharge investigations in sub watershed.
2. To prepared the groundwater potential zones in the sub watershed.
3. To identify the interrelationships of recharge areas with geology, geomorphology, soils and structure of the sub watershed.
4. To suggest suitable sites and methods for artificial recharge to augment groundwater recharge with Village Tank, cement nala bund etc. in the sub watershed.

Methodology

The methodology adopted in the present study is presented schematically and described in the following steps: The LISS-III (2013-14). 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 Man watershed area. The maps were georeferenced and digitized using the Arc GIS 10 and attributes were assigned to create the digital database. 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.Various features are identified and distinguished using interpretation key and visual interpretation technique.

Geomorphology

Geomorphology deals with the general configuration of the earth surface. It consists of description and measurement of the morphological features like mountains, rivers, elucidate the processes involved in their development and eventually construct the history of their evolution. Major geomorphologic units found in the study area are flood plain, habitation mark, Denudational hills Alluvial Plain, plateau and water body. The geomorphological map of the Man river basin 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.These units are considered as poor potential zones, as they have unfractured rock material, low infiltration and behave largely as runoff zone. Structural hills are the linear or acute hills exhibiting definite trend lines and mostly act as runoff zones. Linear ridges are characterized by massive structure and high resistance to erosion. They also act as runoff zone and have poor potential for groundwater. Piedmont plain has low relief and surface water remains for considerable time before meeting major rivers. It provides good scope for infiltration and recharge of groundwater. Consequently they pose good potential for groundwater occurrence (Fig.2).

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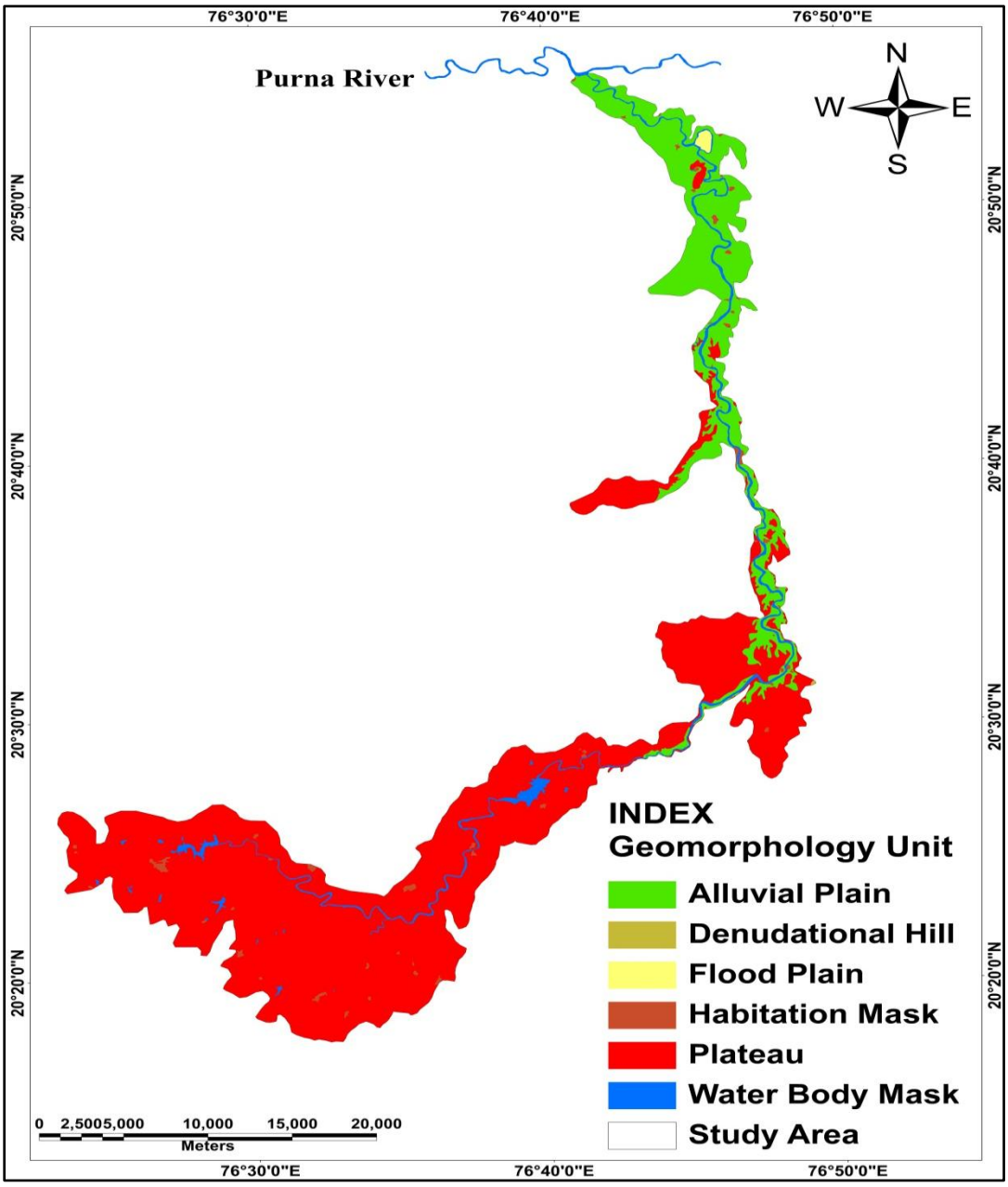

Fig.2 Geomorphology map of Man River basin

Lineament Distribution

A lineament is defined as a large scale linear structural feature. Such features may represent deep seated faults, master fractures and joints sets, drainage lines and boundary lines of different rock formations. Lineaments provide the pathways for groundwater movement and are hydrogeologically very important (Sankar,2002). Lineaments are important in rocks where secondary permeability, porosity and intergranular characteristics together influence groundwater movements. The lineament intersection areas are considered as good groundwater potential zones. The combination of fractures and topographically low grounds can also serve as the best aquifer horizons. Lineaments have been identified on images through visual interpretation by comparing spatial variation in tone, colour, texture, association, etc. 60 m area on either side of lineaments and intersections of lineaments are considered to be favourable for accumulation of groundwater. The study area is traversed numerous

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lineaments/Fractures oriented along N-S, NW-SE, NNW-SSE, and E-W directions. It is believed that these lineaments might have been resulted due to plate movements and tectonics in the region (Ganesha Raj, 1994) (Fig.3).

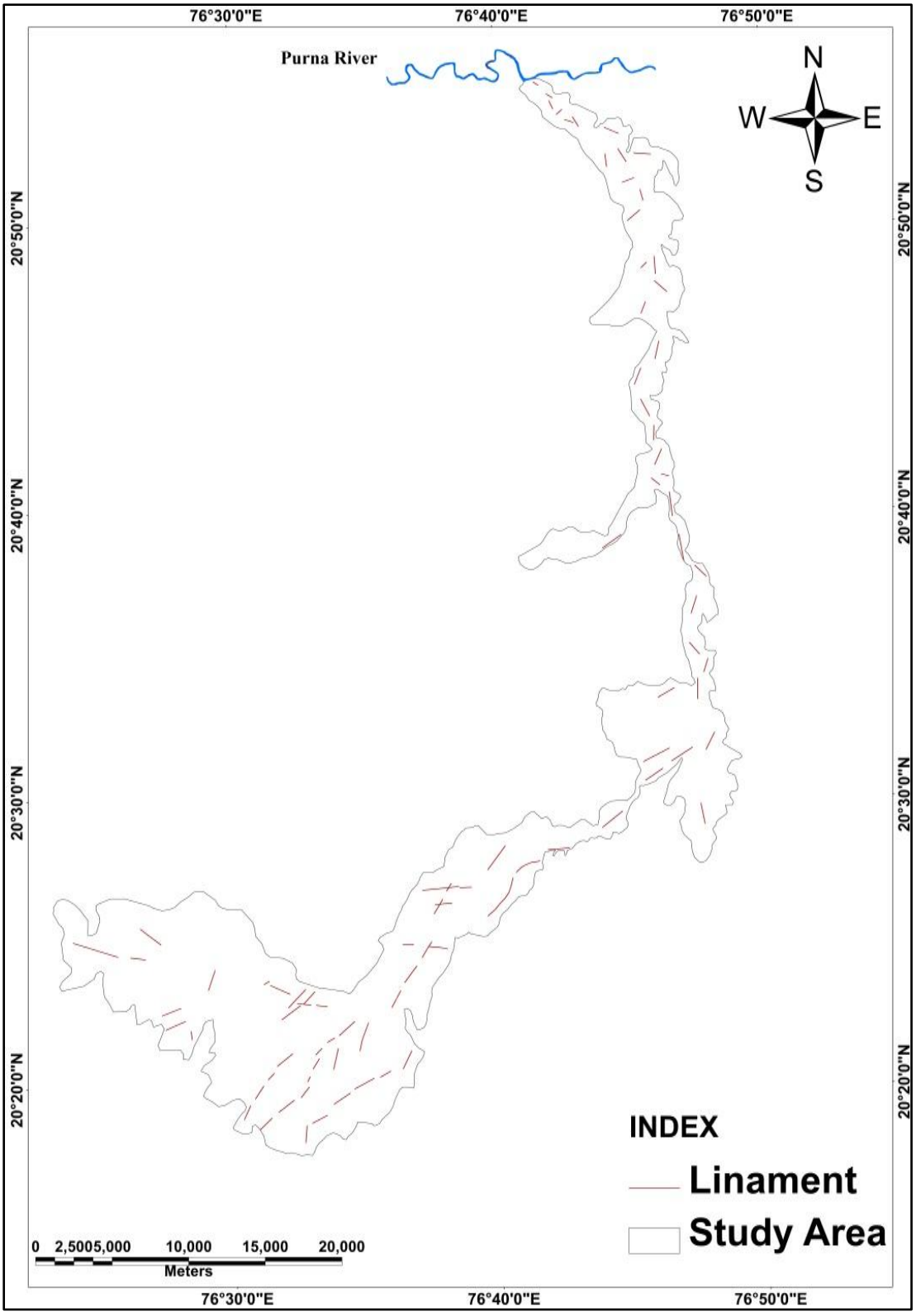

Fig.3Lineamentmap of Study Area

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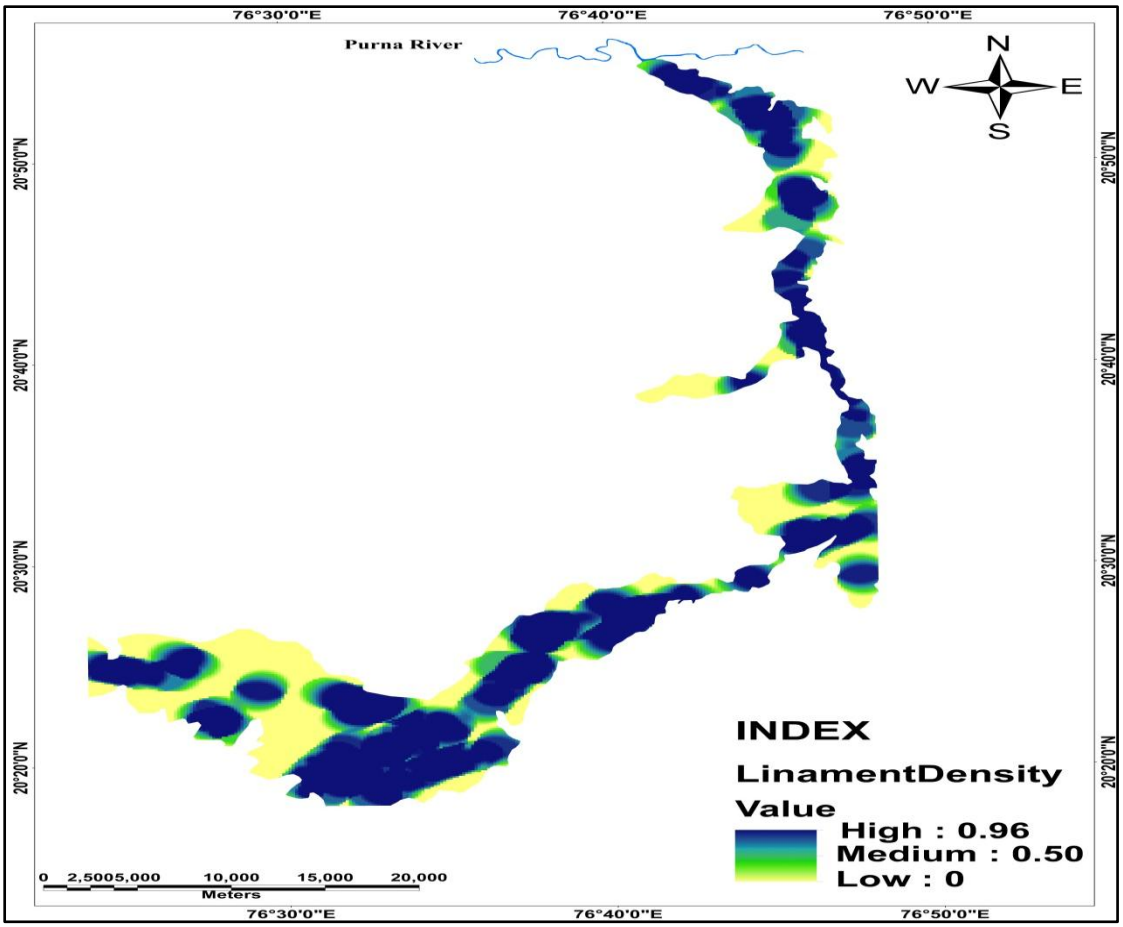

Fig.4Lineament Densitymap of Study Area

Groundwater Potential zone mapping

The drainage basin morphology being an important aspect of geomorphic analysis has been undertaken in the present context to determine the various properties of form elements, their distributional variation, interrelationship, determination of correlation coefficients etc. Remote sensing studies provide an opportunity for better observation and more systematic analysis of various hydrogeomorphological units coupled with geological parameters in this study area which is considered very useful technique in preparing integrated hydro-geomorphological maps for targeting groundwater.The study area was broadly divided into several hydrogeomorphic units which are based on the visual interpretation of satellite imagery, topographical map and field check. The delineation of the hydrogeomorphic unit aimed at demarcating areas of ground water potential zones for development. These hydrogeomorphic units were identified and verified during field checks and then a hydrogeomorphological map was prepared.

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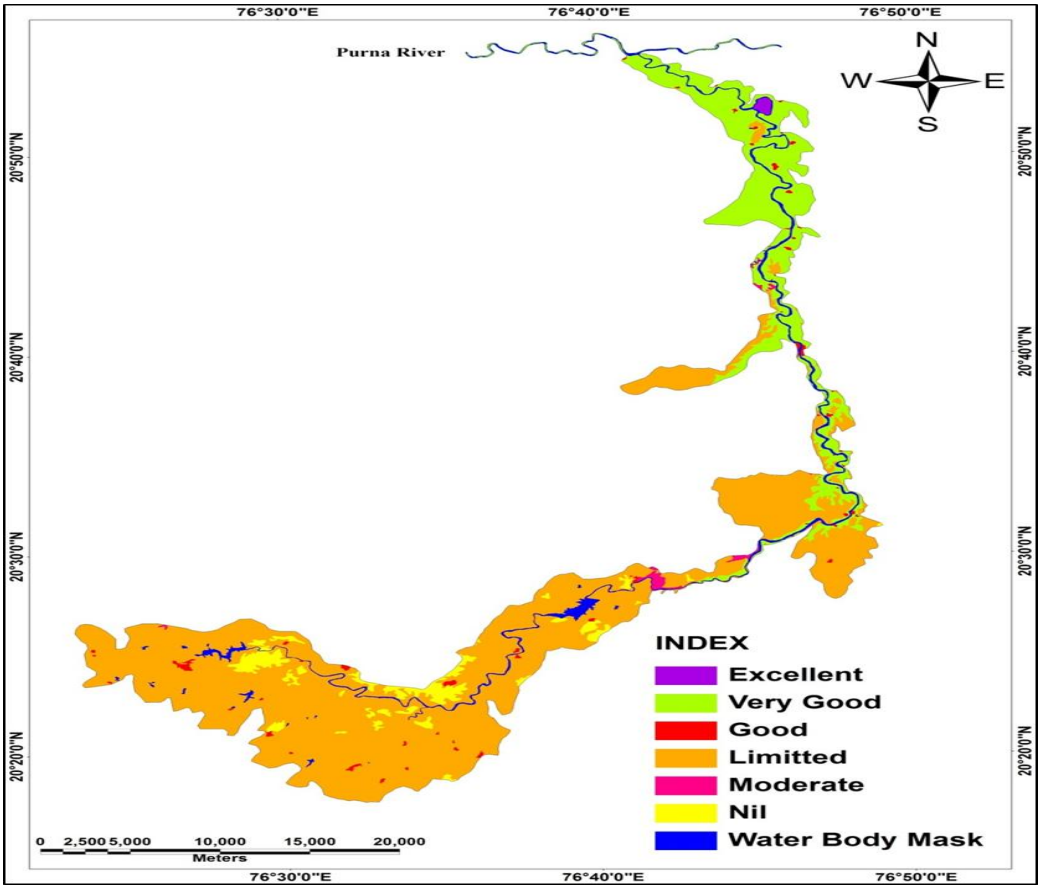

Fig.5Groundwater Potential zone map of study area

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 Man river basin.The site selection is purely based on hydro geological point of view, the engineering aspects are not considered here. (Fig.6).

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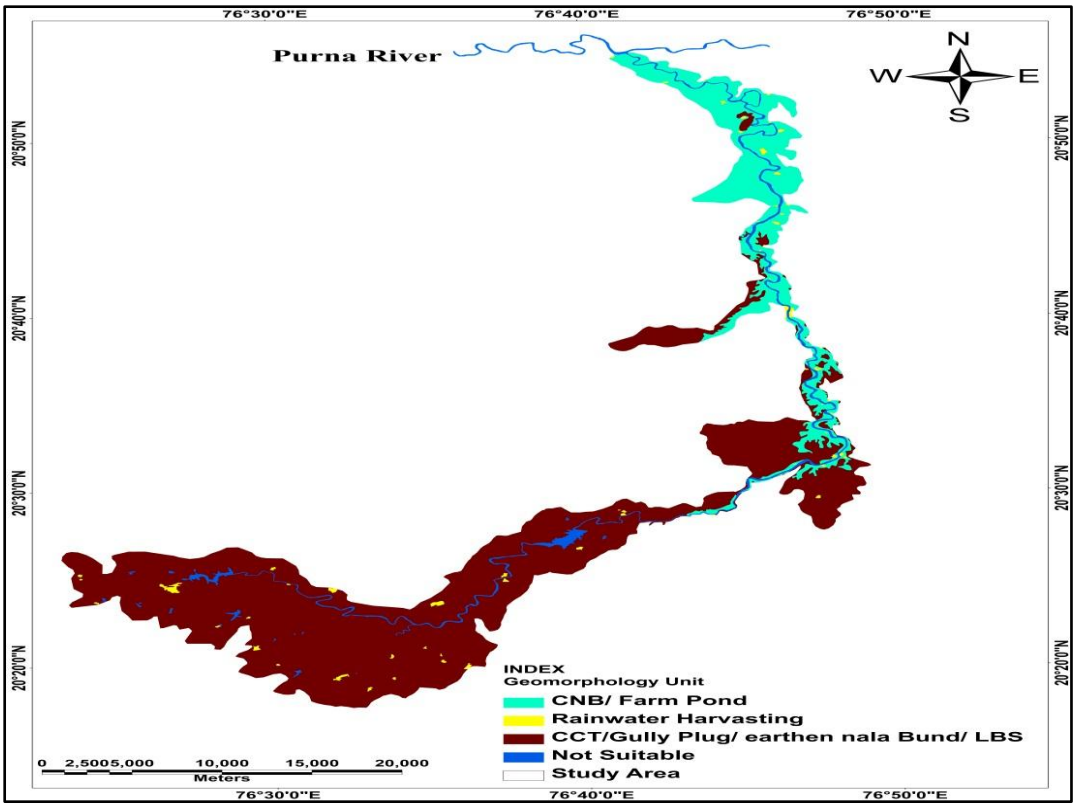

Fig.6Artificial recharge map of study area

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.

Conclusions

In order to delineate the groundwater Recharge zones, different thematic layers viz: geomorphology, lineament and lineament density map are used to be integrated. This provides a broad idea about the groundwater prospect of the area. Presently groundwater Recharge zones have been demarcated by integration of above thematic layers, using a model developed through GIS technique. The above study has demonstrated the capabilities of using remote sensing and Geographical Information System for demarcation of different artificial recharge zones of groundwater. This gives more realistic groundwater recharge zone map of an area which may be used for any groundwater development and management programme. 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, geomorphology has been found very useful in the selection of suitable sites for artificial recharge. Moderately high-resolution satellite images data (LISS-III and Land sat image) provide details of the terrain, as well as a synoptic overview, to visualize the general groundwater condition indirectly.

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