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Assessment of ground water recharge structure using GIS and remote sensing on Pedhi river, Amravati, Vidarbha region, India

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Abstract

Water is one of the abundantly available substance in nature. It is essential constituent of all animal and vegetable matter and forms about 75% of the matter of Earth's Crust. Maharashtra has always faced droughts. The drought has persisted for four consecutive years and has affected drinking water security and crop production and productivity severely all over the Maharashtra state. Vidarbha is the region in Maharashtra which also faces drought after every four to five years. Amravati district is one of the Maratha Wada region also suffering from the same problem of irrigation and agricultural productivity. Annual average rainfall in the Amravati District is Approximately 857.4 mm. this rainfall is not constant and every four to five years less rainfall occurs in this area. If we see technically this rainfall is sufficient in all respect, but due to the improper practices, unavailability of water storing structures and lack precision in agricultural practices cause decrease in overall agricultural yield and deficiency of water has been observed. Study area is situated in the Vidarbha region which also faces draught after four to five consecutive years. Study area is located in Maharashtra, India. 20°48'25" and 20°9'54" North latitudes and 77°27'51" and 77°43'27" east longitude covering an area of approximately 904 km² and fall in survey of India Toposheet No. 55 G/12, 55 G/16, 55 H/9 and 55 H/13 and having population 1,13,109 as per 2011 census. Amravati is a city and a municipal council in Amravati District in the Indian state of Maharashtra. The objective of the work is to study and to prepare various map like delineation of groundwater, contour, aspect, hill shade etc. using GIS and give the suggestions of sustainable development of Agriculture in Amravati. The software use for the work is ArcGIS 10.3 which is developed by ESRI (Environmental Space Research Institute located in Redlands, California. Land use and Land cover map is prepare to study the how land in Amravati is distributed like Agricultural, Road, River, Open Space etc. this LULC map shows that area covered by barren land is most dominant among all other types. Which comes to conclusion that there is scope for increasing crop productivity. The thematic maps prepared from DEM were useful in assessing the topographic, geologic and drainage characteristics of the area under study. DEM based maps include Aspect map, Hill shade, contour and slope. Study also shows that soil in Amravati District is of three types.

Keywords: Ground Water, Recharge Structure, GIS, Remote Sensing, Pedhi River.

Introduction

Land is one of the most important natural resources, as life and various developmental activities are based on it. Land-cover change has been identified as one of the most important drivers of change in ecosystems and their services. These changes result from population Growth and migration of poor rural people to urban areas for economic opportunities. However, information on the consequence of land cover change for ecosystem services and human well-being at local scales is largely absent. The spa welling process of expansion is disordered, unplanned, leading often to inefficient and sustainable urban expansion patterns. The fundamental objectives of studying land use/land cover changes to is investigate the social,

Economic and spatial causes of changes so that proposals can be made on the suitable use of land and patterns of development. Land use/ land cover change detection studies coupled with spatial analysis serves as an effective tool for scientists and policy makers for efficient an advantage of rapid data acquisition for land use/ land cover mapping.

Groundwater availability in any terrain is largely controlled by the prevalence and orientation of primary and secondary porosity. Groundwater exploration entails delineation and mapping of different lithological, structural and geomorphological units. Satellite based remote sensing data facilitate the preparation of lithological, structural, and geomorphological maps, especially at a regional scale. These data show major rock groups, structural features, such as folds, faults, lineaments and fractures, and different landforms, due to their synoptic coverage and multispectral capability (Siegal and Gillespie 1980, Drury 1987). Visual interpretation of remote sensing images is achieved in an efficient and effective way using basic interpretation keys or elements (Sabins 1987).

Lineament analysis of remote sensing data constitutes an important part of studies related to tectonics, engineering, geomorphology and in the exploration of natural resources such as groundwater, petroleum and minerals (Koopmans 1986, Kar 1994, and Philip 1996).

Groundwater is the water that exists underground in saturated zones below the land surface inside aquifers (Bouwer, 2002). Principally, the recharging of groundwater resources is accomplished by surface water and rainfall. (McCracken, 2019). The natural replenishment of groundwater is due to the precipitation and percolation of surface water into underground aquifers (Prabhu and Venkateswaran, 2015). Generally, groundwater has a slow movement of 7 cm to 60 cm per day. Since it is difficult to directly observe groundwater resources, monitoring, modeling, and mapping are highly important for managing these resources (Brands *et al*., 2016).

Geographic information systems (GIS) are helpful mapping tools that can be beneficial in carrying out geospatial analysis in many research fields. GIS tools have the capacity to efficiently solve problems that need the integration of several spatially referenced data (Prabhu and Venkateswaran, 2015). Several studies have adopted GIS tools in geospatial analyses related to groundwater quality assessment (Adimalla and Taloor, 2019; Babiker *et al*., 2006 and Nas and Berktay, 2008)

Maps of geomorphology and soil lectures were collected from Punjab remote sensing center, Ludhiana and national Bureau of soil survey and land use planning. Drainage network for the study area was extracted from SRTM, DEM and screen digitalization of topographic map (Panda *et al*., 2009).

The present work is carried out with assessment of ground water recharge structure using GIS and remote sensing on pedhirive in study area. In this study identifying watershed catchment area using SOI Toposheet, preparation of groundwater potential zones map, identifying the interrelationship of recharge areas with geology, geomorphology, soils and structure of the sub watershed, preparing of thematic map of factors affecting the recharge of groundwater, identifying locations where recharge structures can be constructed and suggest suitable recharge structure and delineate the groundwater potential zones in the sub watershed.

Materials and Methods

The study area Amravati is situated between 20°32' and 21°46' north latitudes and 76°37' and 78° 27' east longitudes. The district occupies an area of 12,235 km². The district is bounded by Betul District of Madhya Pradesh state to the north, and by the Maharashtra districts of Nagpur to the northeast, Chindwada district of Madhya Pradesh to the northeast Wardha to the east, Yavatmal to the south, Washim to the southwest, and Akola and Buldhana districts to the west. The Pedhi river is rises in hills near Rithpur in Morshi tahsil. The Pedhi flows in easterly direction, after crossing the district it turns westwards and north-westwards to join the Purna river, Rithpur, Walgaon and Bhatkuli are few important villages at banks of the river. It is one of the water-supply sources to the city of Amravati.

Land use / land cover mapping: cloud free LANDSAT satellite data (geo coded with UTM projection), (spheroid and datum WGS 1984, zone 43 north) of 30m spatial resolution of year 2017 has been downloaded from USGS Earth explorer website (http://earthexplorer.usgs.gov/).

Landsat 8 ETM+ images consist of eight spectral bands with a spatial resolution of 2. 30 meters for bands 1 to 7. The panchromatic band 8 has a resolution of 15 meters. The details of satellite data. 3. DEM model for development of aspect, hill shade and slope map were downloaded from USGS Earth explorer official website of NASA operations: http://gdex.cr.usgs.gov/gdex/ Toposheet of scale 1:50,000 were acquired from www.lib.utexas.edu/maps/ams/india. Soil type sheet of Maharashtra: official ESDAC website (http://esdac.jrc.ec.europa.eu/search/node/mahara shtra).

Methods: Process: Georeferencing: Geo referencing means the internal coordinate system of a map or aerial photo image can be related to a ground system of geographic coordinates. The relevant coordinate transforms are typically stored within the image file (Geo PDF and Geo TIFF are examples), Though there are many possible mechanisms for implementing geo referencing. The most visible effect of geo referencing is that display software can show ground coordinates, such as latitude/longitude or UTM coordinates) and also measure ground distance and areas. Doing this thing with USGS Geo PDF maps requires the free Terra Go toolbar extension to Adobe Reader. In other words, Georeferencing means to associate something with locations in physical space. The term is commonly used in the geographical information systems field to describe the process of associating a physical map or raster image of a map with spatial location. Georeferencing may be applied to any kind of object or structure that can be related to a geographical location, such as point of interest, roads, places, bridges or buildings. Geographic locations are most commonly represented using a coordinate reference system, whichin turn can be related to a geodetic reference system such as WGS-84.

Rectification: Image rectification is a transformation process used to project two-or-more images onto a common image plan. This process has several degrees of freedom and there are many strategies for transforming images to the common plane. It is use in computer stereo vision to simplify the problem of finding matching points between images (i.e. the correspondence problem). It is used in geographic information system to merge images taken from multiple perspectives into a common map coordinate system. if the images to be rectified are taken from camera pairs without geometric distortion, this calculation can easily be made with a linear transformation. X and Y rotation puts the images on the same plane, scaling makes the image frames be the same size and Z rotation and skew adjustments make the images pixel rows directly line up. The rigid alignment of the cameras needs to be known (by calibration) and the calibration coefficients are used by the transform. In performing the transform, if the cameras themselves are calibrated for internal parameters, an essential matrix provides the relationship between the cameras. The more general case (without camera calibration) is represented by the fundamental matrix. If the fundamental matrix is not known, it is necessary to find preliminary point correspondences between stereo images to facilitate its exaction. There are three main categories for images rectification algorithms: planer rectification, cylindrical rectification and polar rectification.

Clip: Extract input features that overlay the clip features. This tool is used to cut out a piece of one feature class using one or more of the features in another features class as a cookie cutter. This is particularly useful for creating a new feature class, subset of the features in another, larger feature class. The clip features can be points, lines, and polygons depending on the input features type.

Mask: In Arc Map, visible-depth masking is a drawing technique used to hide parts of layers that are drawn underneath symbols and annotation. This topic describes how to use polygons to mask underneath maps layers to overlay dense symbols and to make maps more readable and useful. Masking is used to clarify maps that are densely packed with annotation and symbology. You can use a polygon mask layer to mask out particular aspects of one layer and add a layer of map text and other symbols on top of it. The goal is to make the map more readable. For example, many of the annotated polygons in the map below are filled with a pattern. Using a mask to remove the patterns around the annotation features makes the map easier to read and use.

Mosaic: Merges multiple existing raster datasets into an existing raster dataset that means, A mosaic is a combination or merge of two or more images. Mosaic dataset consist of three layers: boundary, footprint and images.

Observations and Result

Output and application: Local, regional as well urban planners require current information to manage urban development and plan for future urban change. In urban area land cover change is very dynamic and rapid. hence, the dynamic land cover change particularly urban area are further complicated to obtain up-to-date information regarding newly constructed houses, newly established industries, and commercial developments. Therefore, the accurate urban land cover change detection is very significant to formulate strategies that reduce poverty and environmental effect and promote the sustainable development of urban areas. An integrate approach to land use and land cover change detection is best to provide land use information for planners. Whereas remote sensing data is the mean of providing the change in land cover conversion reference to existing land use and land cover changes. Remote sensing (RS) data and Geographical information system (GIS) can deliver good opportunities for integrated analysis of spatial data and product development. This interaction of remote sensing and geographical information system can be described as follows: Remote sensing data can be used as input data or major data sources for analysis within a Geographic information system.

Geographical information system data can be providing additional data improve remote sensing data analysis for distinguishing between land cover and land use classes. Remote sensing and Geographical information system in combined applied to change detection analysis and modelling urban growth. Additionally, Remote sensing output has been used to help in the formulation of policies and provide insight into land-cover and land-use pattern, and multi temporal trends. here has been an evolution in the manner in which remote sensing, associated technologies and analysis techniques are being used to map land cover and land use change at local, landscape, regional and continental scales.

Todays, remote sensing imagery from satellite and airborne platform provide digital data at scales of observations that meet various mapping criteria for characterizing anthropogenic and natural surfaces. In particular, remote sensing based multi-temporal land use change data provide information that can be used for assessing the structural variation of LULC patterns, which can be applied to avoiding irreversible and cumulative effects of urban growth and are important to optimize the allocation of urban services. In addition, accurate and comprehensive land use change statistics are useful for devising sustainable urban and environmental planning strategies. It is therefore very important to estimate the rate, pattern, and type of LULC changes in predict future changes in urban development.

Natural water available: Amravati District comes under drought prone interior and thus is largely affected with water scarcity. The AAR of Amravati according to Gov. Survey is 634mm. the AAR of Amravati Dist. is 705 mm, which means that Amravati lies below average in rainfall as compared to whole district. The computation of water precipitation thus comes to nearly 974.5 million metric cubes of water received every year in precipitation. Out of this majority of the water is wasted as surface runoff due to lack of storage structures in the taluka. The hard basalt formation in majority of taluka also contributes to the relatively low infiltration of rain water in soil. What remains of it is stored in the mentioned irrigation projects are quite incapable in their areal extent to irrigate whole of the taluka. Thus, the above contributes to the agricultural lagging in terms of production.

Aspect map: The above obtained aspect map of Amravati shows the face direction of slope of surface by representing a range of angular cover by different colors. Aspect map concludes that the maximum slope in the region lies along the North-South direction and thus their face is in the East-West direction.

Hill shade map: The hill shade of Amravati was obtained in the above map which shows the elevation features of the region in a much-differentiated manner. The region under Yellow colour represents the area that comes under shadow region and that in Blue signifies face towards the lighting source.

Slope map: The above map when observed clearly shows that northern region is covered with slightly sloppy to extreme sloppy area. Thus, the region in northern part of covers hilly terrain and thus has relatively higher slope as compared to other part. The part southward from the hills comes under green color in the map, thus the slope here would vary from negligible to slight slope. The average slope of the region in the southward direction, this adds to the fact that natural drainage would flow from north towards south in the Pedhi River on the south boundary of District.

Contour map: The contour map of Amravati District showing elevation of different part of taluka showed that the contour lines were close to each other in the northern part of the map as compared to relatively spaced contour lines in lower part of the map, which suggest that topography of Amravati ranged from hilly terrain in the northern region which gradually recedes to plains and plateau in southern region of taluka. The southern boundary of District is traced along by river, which disposes majority of drainage flow from the District. The highest elevation point of District was at an elevation of 1120 m from mean sea level (MSL) and the lowest point was 280 m from MSL.

Digital elevation model: The above graph obtained from processing of digital elevation model shows the count of contour line i.e. no. of contour lines having the mentioned value against x-axis on the y-axis. The graph shows that maximum high peaks are seen in the region of elevation 1163 m to 248 m, which signifies that majority of taluka lies under elevation of the above range.

Conclusion

After the analysis following conclusions were drawn:

- The average annual rainfall in that region is approximately 857.4 mm. by this rainfall amount of water collected within the taluka boundary was 974490 million litters.
- From the study of land use and land cover map it was found that the ratio of barren land to agriculture land is unity and area contributed by water bodies is negligibly small of total area. a] Road b] Residential area c] Agricultural/vegetation d] River e] Open space.
- About three types of soil are found in Amravati taluka and type second and seventh have dominant area extent.
- From study of geology it is shown that only two types of rocks are found in the area. first is basalt and second is alluvial but basalt rock formation is major. a) Basalt area. b) Alluvial area.
- From elevation study the highest elevated point is at 359m level and lowest point is 274 m above mean sea level.
- The thematic maps of geology, geomorphology, soil, slope, land use/land cover and soil were considered for identifying groundwater potential zones are classified as excellent, good, moderate and poor.

These are useful for solving the water problems of the village and to satisfy the water demands in draught condition. As we concluded from the results that the water bodies' area in the taluka is nearly negligible and the irrigation projects have a reach of only about 5% area. So therefore, a major part of cultivators is dependent on rain and a ground water as their primary irrigation source. It was also observed that majority of drainage network ran dry throughout the year except monsoon. Thus, citing the drought conditions the main attention should be to increase the ground water recharge. This can be achieved by construction and maintenance of new and present water conservation structures like bandanas, check dams, gabions, cct's, seepage basins, roof water and rainwater harvesting, watershed management, etc. on the drainage lines in southern part of the taluka which falls under negligible to gentle slopping land.

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