iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** XI **Month of publication:** November 2023

DOI: https://doi.org/10.22214/ijraset.2023.57160

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue XI Nov 2023- Available at www.ijraset.com

Assessing Suitable Groundwater Recharge Locations and Structures Using GIS Technique in a Semi-Arid Region

Jangam Satish[1], Dr. Kavita Toran[2]
[1]Research Scholar, [2]Assistant Professor, Department of Geoinformatics, Telangana University

Abstract: Groundwater management is the continuous research problem in semi-arid regions of India especially in Telangana State. The observed phenomenon can be ascribed to a combination of climatic factors, such as erratic rainfall and soaring temperatures, along with human factors like large-scale cultivation of paddy crops using traditional methods and the extensive drilling of numerous bore wells. Few parts of Nalgonda revenue division in Telangana State are experiencing such conditions which pulled for the augmentation of groundwater resource by suggesting suitable artificial groundwater recharge structures by adopting geographical information system technique and Central Ground Water Board guidelines. Nala bunds, check dams and water absorption trenches are the appropriate recharge structures for the study area that were identified using drainage network, lineaments, slope and land use land cover. In conclusion, this study has proven the reliability of GIS technique when followed with proper guidelines is effective in finding the suitable groundwater recharge structures.
Keywords: Groundwater, semi-arid, recharge, structures, GIS, CGWB and Telangana

I. INTRODUCTION

Recharge structures play a key role in groundwater replenishment by enabling the percolation of surface water, such as rainwater or river water, into the subsurface (Kumar et al., 2008; Madhnure et al., 2016). They also contribute to controlling surface runoff and preventing soil erosion. GIS technique enables for the spatial analysis of groundwater recharge locations in the research unit. Haphazard urbanization, unpredictable rainfall intensity, ascending temperatures, intensive groundwater extraction, violation of policy norms for bore well drilling, disregard for efficient agricultural water management practices and inadequate soil and vegetation cover are contributing factors to groundwater exhaustion in the semi-arid regions of the Deccan plateau. The aforementioned conditions are persisting in Nalgonda revenue division of Nalgonda District. So, a comprehensive approach is required to address groundwater depletion, and achieving effective recharge can be realized by integrating Geographic Information System (GIS) technology with the guidelines (2007) provided by the Central Ground Water Board (CGWB) to propose artificial recharge structures.

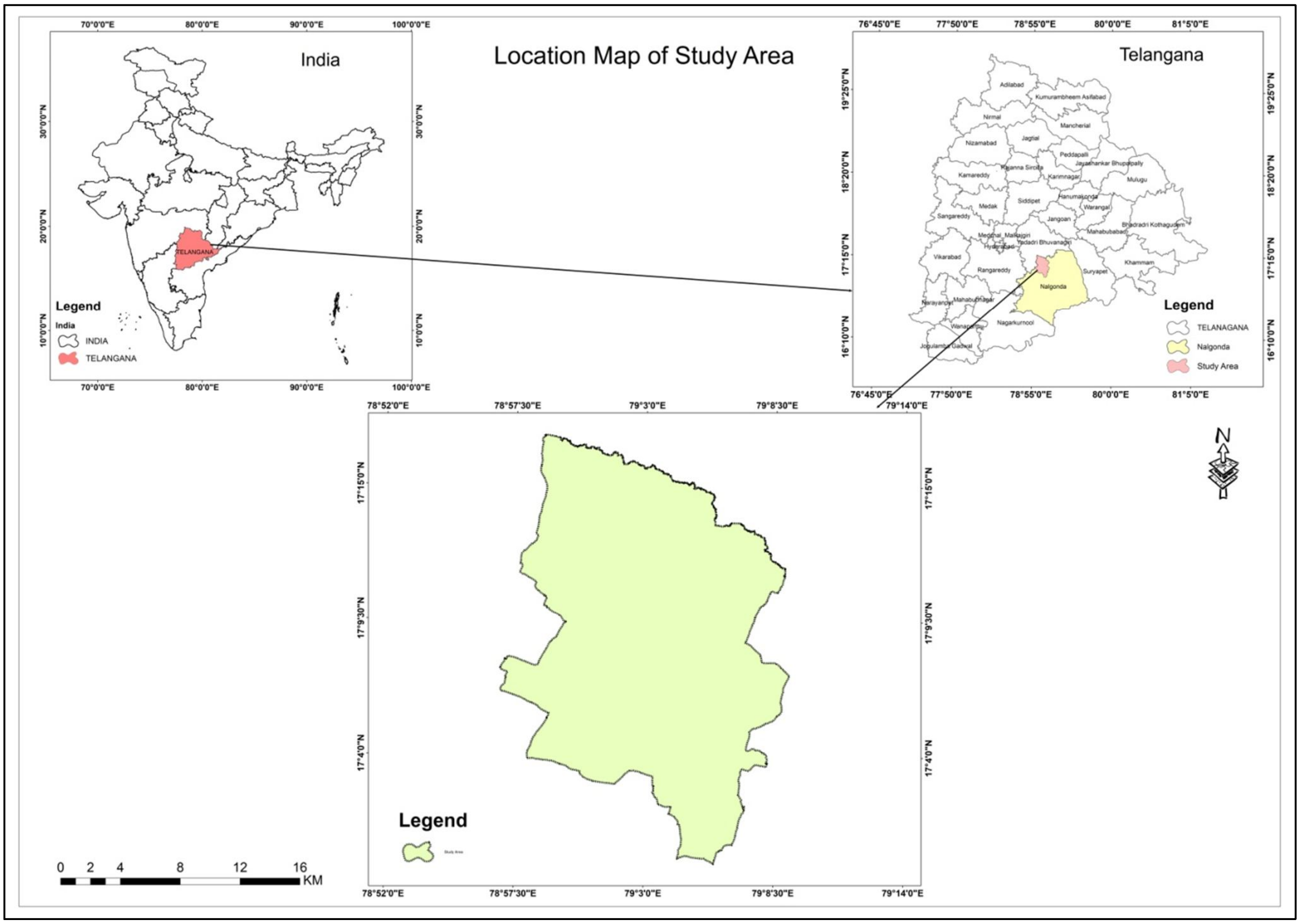
Several researchers have followed, adopted, and customized various methods for selecting relevant groundwater recharge structures (Shankar & Mohan, 2005; Al-Adamat et al., 2010; Ahmad, 2013; Chilukuri et al., 2021; Mati et al., 2006). The objective of this research study is to evaluate appropriate recharge locations and structures necessary for enhancing the groundwater recharge rate. Proposing recharge structures is a proactive approach to establish long-term water security (Kota et al., 2017).

II. STUDY AREA

The periodic water stress conditions, resulting from uneven rainfall, rising temperatures, non-perennial Kanagal River, and burgeoning population, have collectively driven the exploitation of groundwater resources in the research area. This has positioned the area as a focal zone for addressing the water crisis. Figure 1 displays the study area, that is located in the central portion of Nalgonda Revenue Division in Nalgonda District, Telangana state, and is defined by longitudes ranging from 78°56'43.862"E to 79°7'23.649"E and latitudes ranging from 17°17'1.143"N to 17°0'15.565"N.It envelops an area of 419 sq.km andis located 20 km distant from the district headquarters of Nalgonda, namely Nalgonda Town. It experiences hot semi-arid climate. The complex lithology, constituting hard rocks such as granites and gneisses, along with shallow aquifers in the region inhibits the groundwater replenishment. Pediplain covers the vast portion with pediments, residual hills and dykes interspersed in the northern territory and flood plains in the southern territory.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue XI Nov 2023- Available at www.ijraset.com

Figure 1



III. MATERIALS AND METHODOLOGY

Sentinel-2Asatellite image (https://dataspace.copernicus.eu/) of 10m resolution was utilized for preparing land use land cover map. Cartosat-1 CartoDEM*v*3 available in the ISRO's Bhuvan portal (https://bhuvan-app3.nrsc.gov.in/data/download/index.php) facilitated in generating the stream orders using hydrology tools and slope categories by slope tool of ArcGIS 10.2 software. Lineaments layer that is readily available in Geological Survey of IndiaBhukosh portal (https://bhukosh.gsi.gov.in/Bhukosh/MapViewer.aspx) was downloaded and added as input in ArcGIS 10.2 software. Supervised and unsupervised classification of digital image processing techniques was performed to delineate the five classes of land use land cover viz., water bodies, built-up, vegetation, agricultural land and barren/scrub land using ERDAS IMAGINE 2014 software.The land use land cover map was integrated with the slope, lineaments, and stream order layers created in ArcGIS 10.2 software.All layers were standardized to the UTM zone 44N projection for conducting spatial analysis using the Boolean logic principle, in accordance with CGWB guidelines (2007).

IV. RESULTS AND DISCUSSION

Slope, land use land cover, lineaments, and stream orders are crucial factors in substantiating the selection of groundwater recharge locations and structures. Therefore, understanding these factors is of paramount importance.

A. *Geographical Analysis of Influencing Factors*

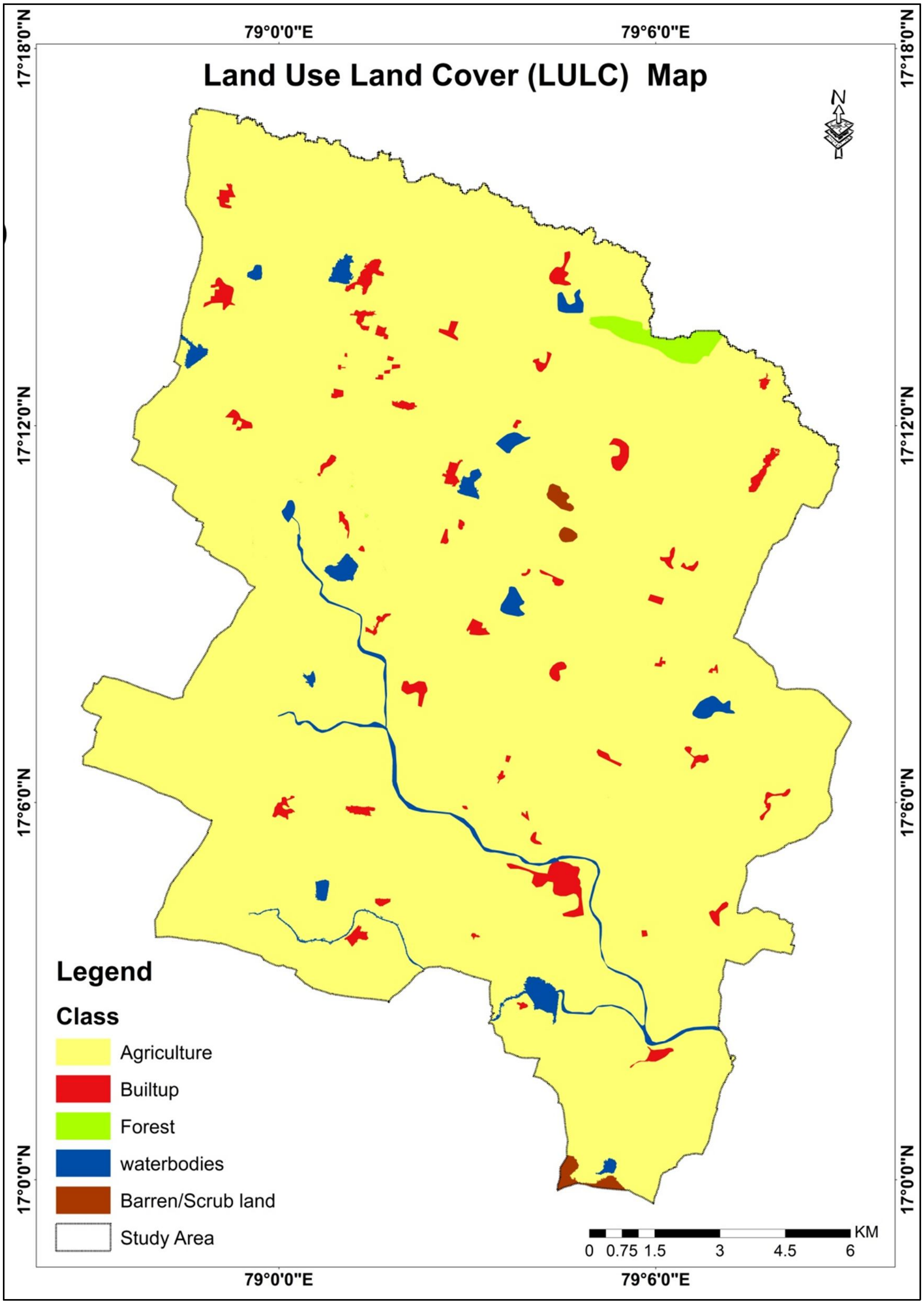
1) *Land Use Land Cover*

The natural and artificial features such as waterbodies, forest, barren land, built-up and agricultural land has certain influence on the rate of the natural groundwater recharge (Scanlon et al., 2005; Lerner & Harris, 2009). The vast and extensive land area, as depicted in Figure 2 and covering 400.30 km^2, is utilized for agricultural practices, considering that agriculture farming is the primary occupation of the population.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue XI Nov 2023- Available at www.ijraset.com

A small linear stretch of forest area present in the northern portion and few patches of barren/scrub land in the central portion together enclose 4.24 km^2 as represented in Table 1.Forest area doesn't contribute for groundwater replenishment as it is occupied in the residual hills. Waterbodies and built-up areas are spread across the region but cover only 1.80% (14.57 sq.km) of research unit.

Figure 2



International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue XI Nov 2023- Available at www.ijraset.com

Table 1. Spatial Extent of Land Use Land Cover Classes

CLASS	Area (Sq.km)
Barren/Scrub land	2.13
Forest	2.11
Waterbodies	7.05
Built-up	7.52
Agricultural land	400.30
Total	419

2) Slope

The inclination of slope attributes to the infiltration rate of surface water into the aquifer.As the slope descends the percolation also increases. Flat and gentle slopes, conducive to higher replenishment (Winnaar et al., 2007), are extensively distributed, enclosing 99.33% (416.22 sq. km) of the research area as shown in Table 2. The negligible factor in groundwater recharge, represented by steep slopes, is confined to the residual hills in the northern portion, covering the smallest land area, i.e., 0.33 sq. km. The remaining section, comprising 0.6% (2.55 km^2), corresponds to a moderate slope situated at the junction between steep and gentle slopes shown in Figure 3.

Figure 3

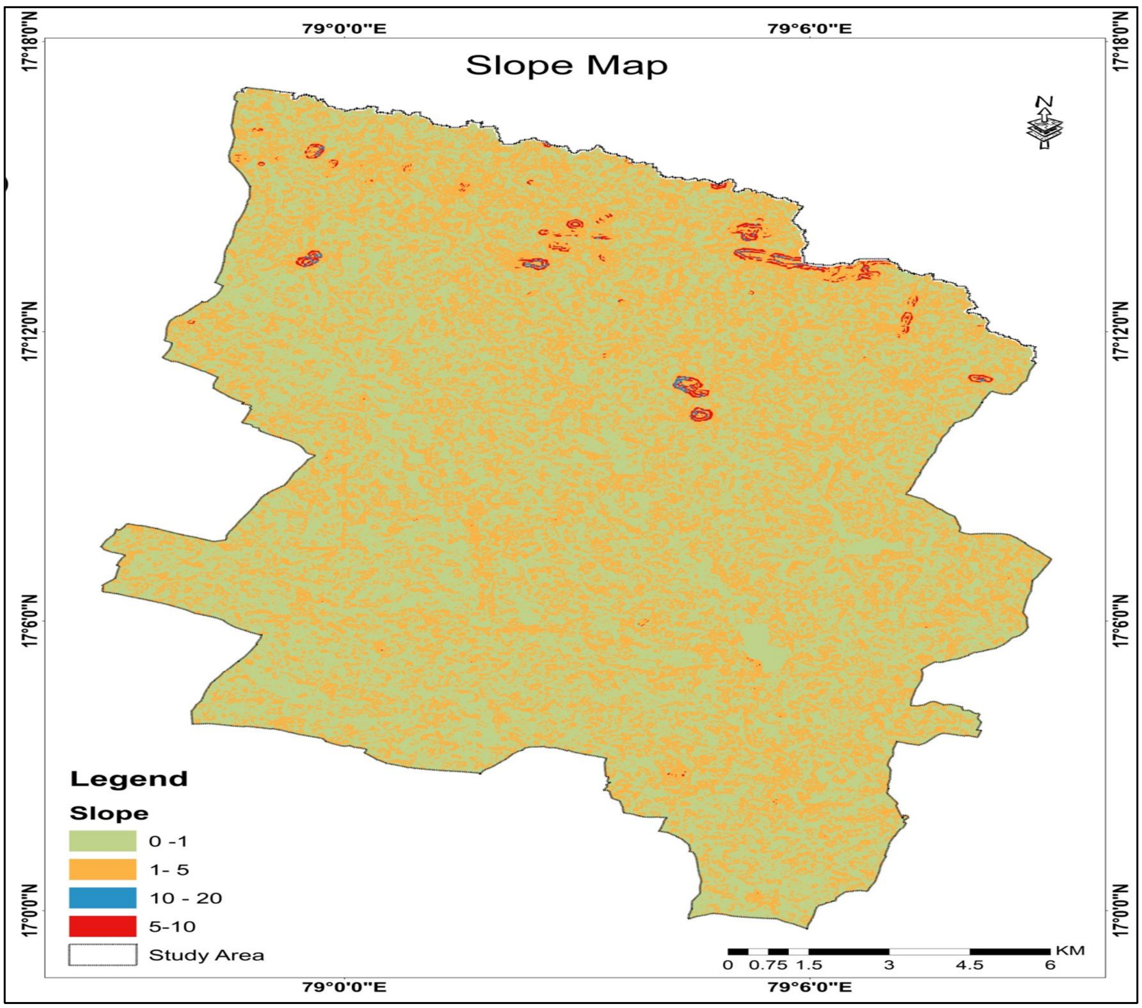


Table 2. Spatial Extent of Slope Categories

CATEGORY	Area (Sq.km)
Flat (0-1deg)	246.40
Gentle (1-5deg)	169.82
Moderate (5-10deg)	2.55
Steep (10-20deg)	0.33
Total	419

3) Stream Network

The stream network exhibits dendritic to sub-dendritic drainage pattern indicating the matured topography. There are six stream orders as identified using hydrology tools and by adopting Strahler method (Strahler, 1957) of stream order classification in ArcGIS 10.2 software. Table 3 and Figure 4 shows the stream length decreased from 1storder (234.48 km) to 6thorder (2.74 km) as we moved from the northern to the southern section of the research area due to variations in relief gradient.The lengths of 3rd, 4th, and 5th order streams are nearly identical, indicating a gentle to flat terrain characteristic of a pediplain. This suggests favorable conditions for the installation of recharge structures.

Figure 4

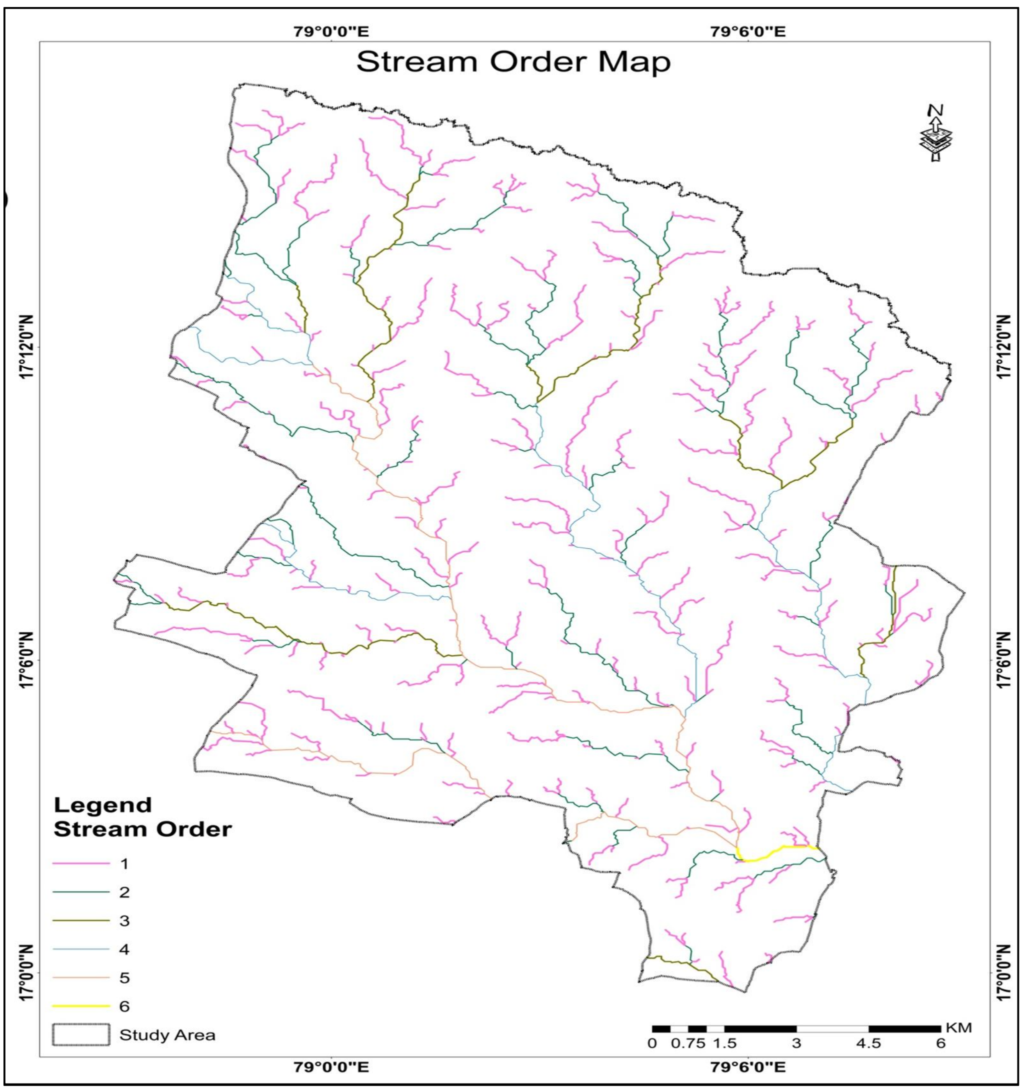


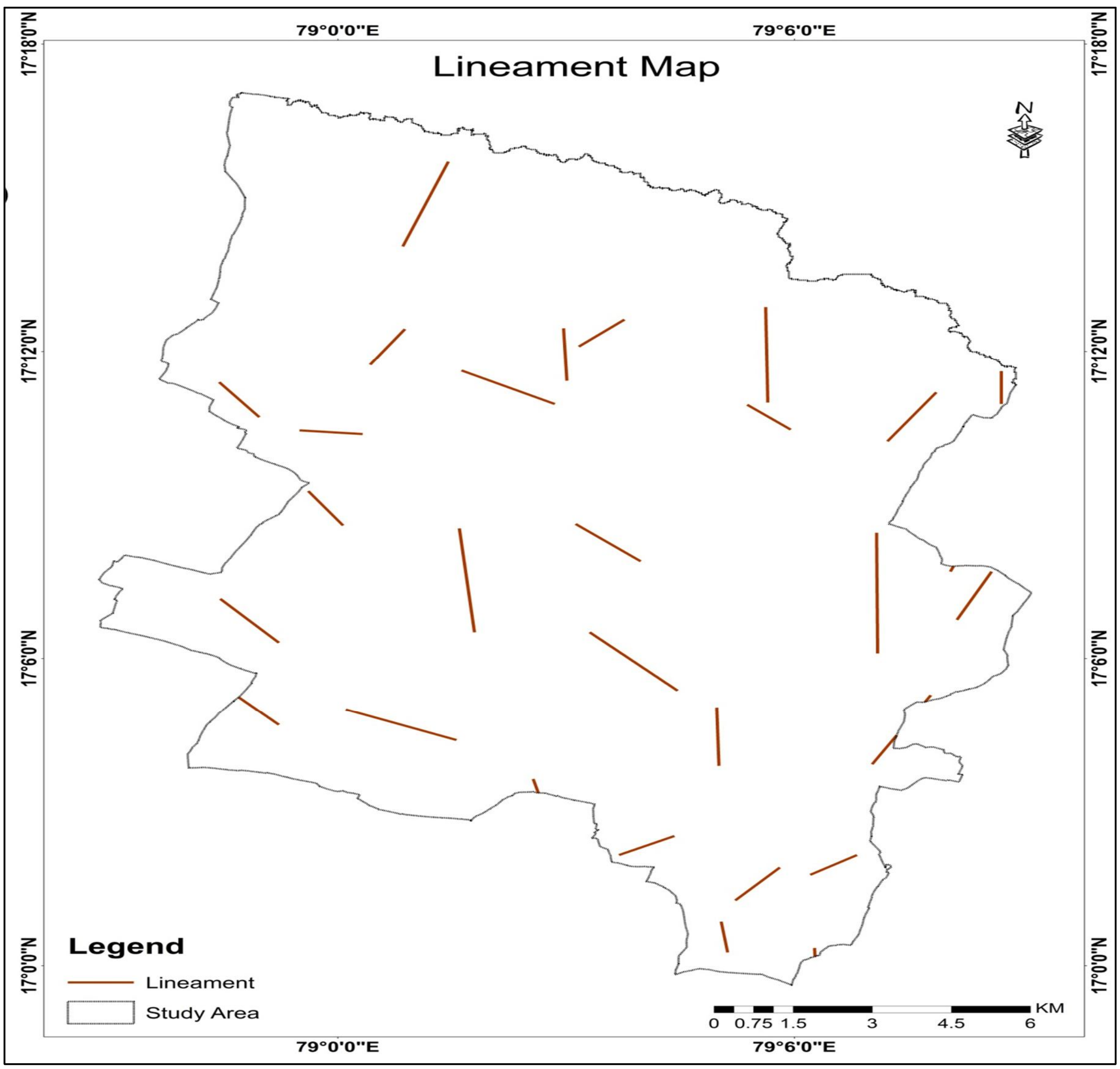
Table 3. Length of Stream Orders

Order	Length (km)
1st order	234.48
2nd order	107.61
3rd order	45.44
4th order	44.83
5th order	42.24
6th order	2.74
Total	477.35

4) Lineaments

Lineaments serve as active zones for direct groundwater percolation into the subsurface, influencing aquifer conductivity (Sander, 2007). They provide insights into the groundwater recharge and occurrence. The length, width, depth, and bottom surface of lineaments disclose the extent of groundwater storage. Figure 5 unveils the size and arrangement, indicating the trend of lineaments in the study area. There are twenty seven lineaments among them major lineaments trend in the north-south direction, while minor lineaments trend northwest-southeast, indicating the orientation of tectonic events. The convergence of lineaments and stream orders represents the most desirable areas conducive to artificial groundwater recharge.

Figure 5

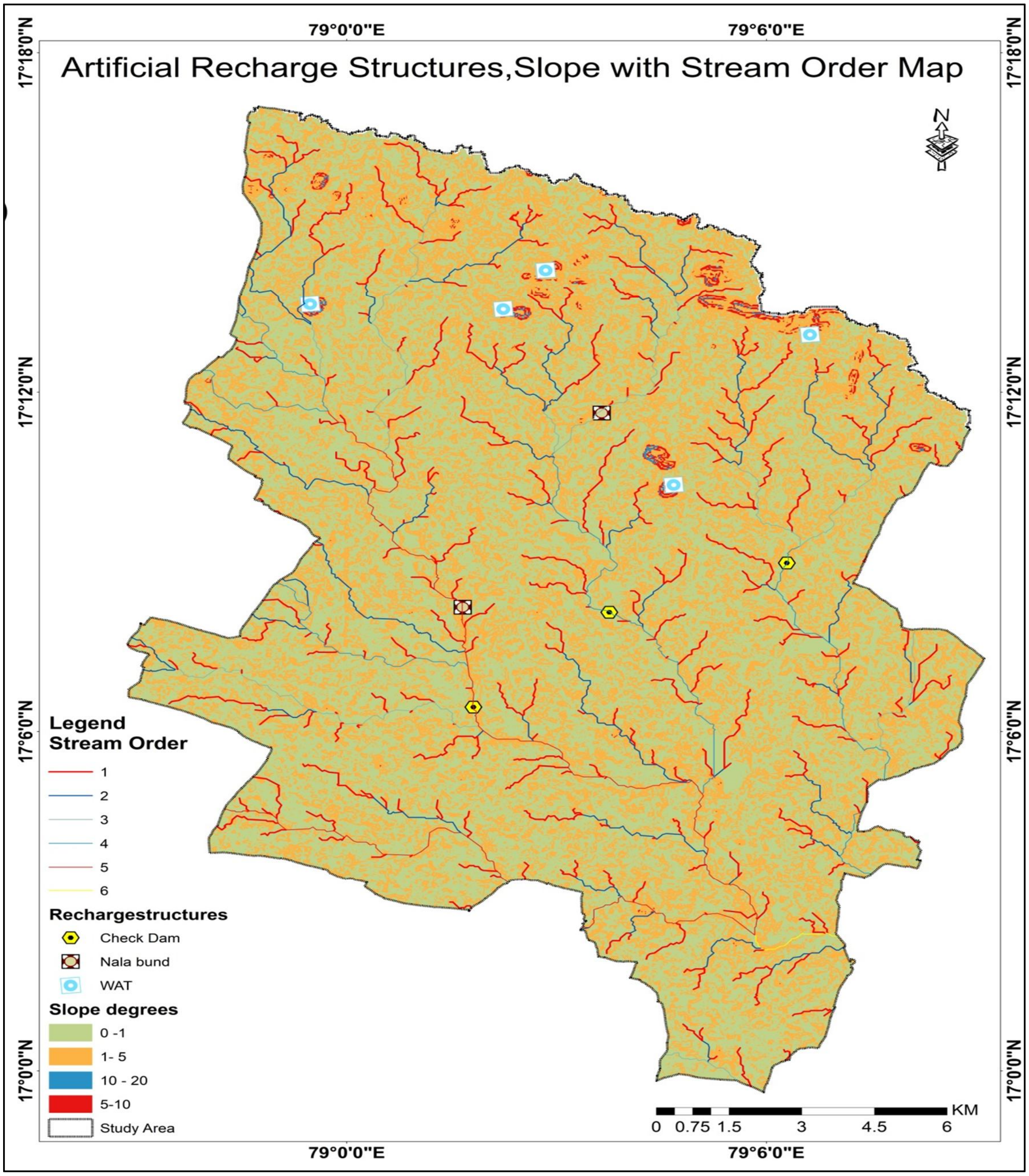


International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue XI Nov 2023- Available at www.ijraset.com

B. Spatial Analysis of Recharge Locations and Structures

Lineaments, stream network, slope, and land use land cover overlay were combined with CGWB guidelines (2007) on artificial recharge and structures. The analysis revealed that water absorption trenches, check dams, and nala bunds as displayed in Figure 6 are suitable for the artificial recharge of groundwater in the study area. High slope, built-up and agricultural land were not taken into consideration while selection locations for artificial recharge and proposing structures. Water absorption trenches are linear structures suitable at the base level of residual hills. Total water absorption trenches suggested are five. The linear portions of 2nd and 3rd order streams and slope of <5 degrees with lineaments were found to be appropriate for recommending nala bunds in two locations. Check dams were recommended based on the fulfillment of certain conditions, including a stream bed width of 5-15m, straight portions of 4th and 5th stream orders, presence of lineaments, a slope of 5-10 degrees, and an agricultural land area of 25-100 ha encircling the check dam. A total of three sites were identified as suitable.

Figure 5



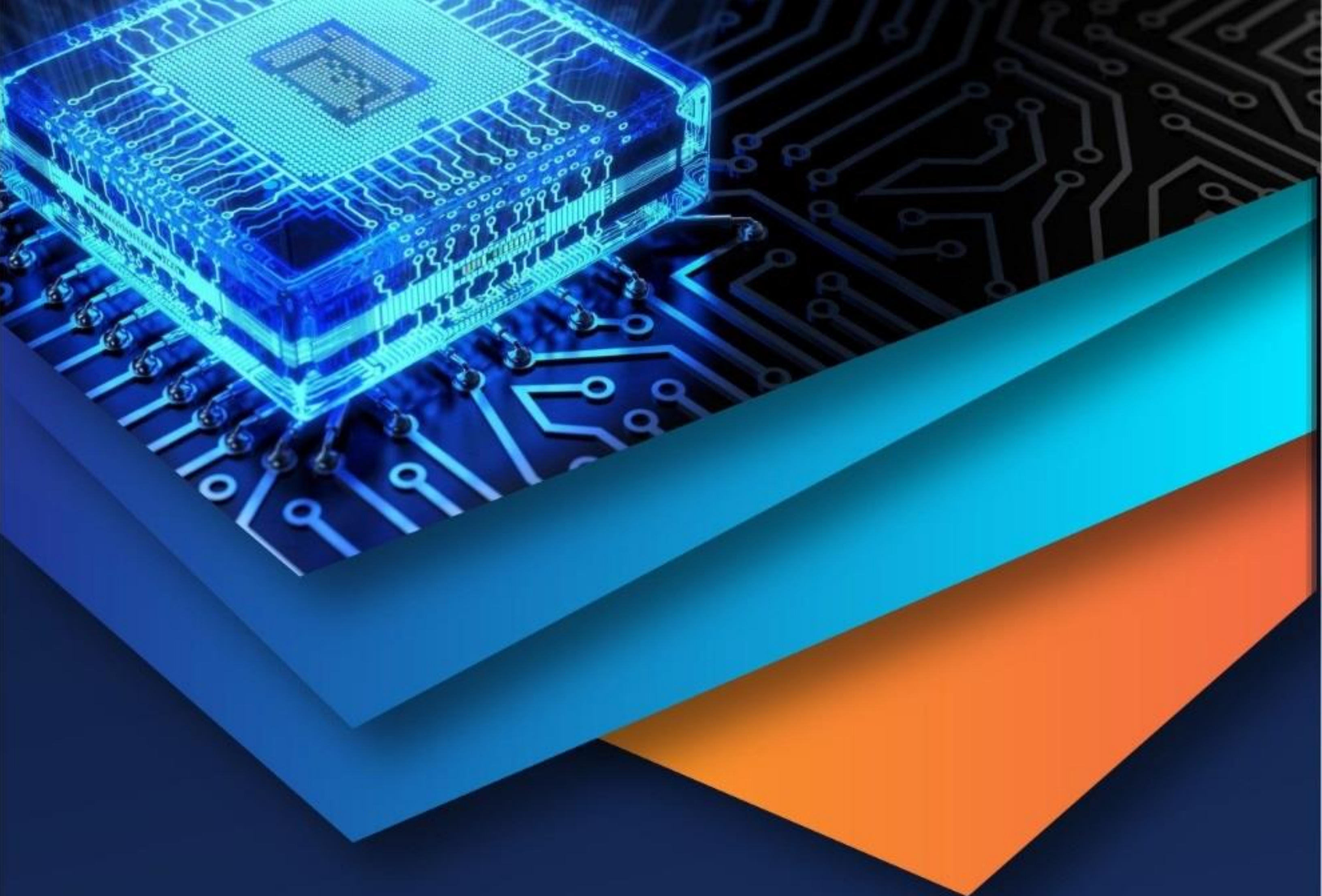
International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue XI Nov 2023- Available at www.ijraset.com

V. CONCLUSION

Sustainable groundwater management, facilitated by structures such as water absorption trenches, nala bunds, and check dams, plays a crucial role in maintaining agricultural productivity, supporting livelihoods, and ensuring access to clean water for various uses.In the research area, these recharge structures constitute essential elements of successful groundwater management strategies, fostering sustainability, resilience, and responsible utilization of this crucial water resource. This method can be applied across diverse geographical conditions to efficiently identify appropriate artificial recharge structures and their corresponding locations within a short time frame.

REFERENCES

[1] Al-Adamat, R., Diabat, A., Shatnawi, G. (2010). Combining GIS with multicriteria decision making for siting water harvesting ponds in Northern Jordan. Journal of Arid Environments 74(11), 1471–1477. https://doi.org/10.1016/j.jaridenv.2010.07.001
[2] Ali, M. A., & Kamraju, M. (2023). Natural Resources and Society: Understanding the Complex Relationship Between Humans and the Environment. Springer Nature.
[3] Ali, M. A., Sethy, K. M., Wamo, M., & Kamraju, M. Urban Environment and Spatial Science.
[4] Ali, M. A., Vani, M., & Kamraju, M. (2018). REMOTE SENSING AND GISSTUDY ON CHANGE DETECTION IN LAND USE LAND COVER IN KONDARAPET MANDAL, KARIMNAGAR DISTRICT, TELANGANA. REMOTE SENSING, 93(2), 118-125.
[5] Central Ground Water Board. (2007). Manual on Artificial Recharge of Groundwater. Government of India: Faridabad, Haryana, p. 198.
[6] Chilukuri, L. K., Vasa, S. K., &Mohd, A. A. (2021). The Hierarchical Segregation of Groundwater
[7] De Winnaar, G., Jewitt, G. P. W., & Horan, M. (2007). A GIS-based approach for identifying potential runoff harvesting sites in the Thukela River basin, South Africa. Physics and Chemistry of the Earth, Parts a/b/c, 32(15-18), 1058-1067.
[8] Dubey (Eds.), Sustainable Climate Action and Water Management (pp. 73-86). Singapore:
[9] Ghani, M. W., Arshad, M., Shabbir, A., Mehmood, N., & Ahmad, I. (2013). Investigation of potential water harvesting sites at Potohar using modeling approach. Pakistan Journal of Agricultural Sciences, 50(4).
[10] Kamraju, M. (2023). Overview of Geospatial Science and Technology. In: Ali, M.A., Kamraju, M. (eds) Temporal and Spatial Environmental Impact of the COVID-19 Pandemic. Advances in Geographical and Environmental Sciences. Springer, Singapore. https://doi.org/10.1007/978-981-99-1934-5_1
[11] Kamraju, M., Kamraju, M., & Vani, M. (2017). Geotechnical Study for Groundwater Management a Case Study of Peddavagu Mini Watershed in Telangana State. International Journal of Innovative Research in Science, Engineering and Technology, 6, 11780-93.
[12] Kishan, A. B., Ali, M. A., & Kamraju, M. (2019). IMPACT OF URBAN GROWTH ON LAND USE-LAND COVER IN HYDERABAD CITY.
[13] Kota, N., Ramudu, N., Ravikumar, S., & Suresh, M. (2017). Hydrogeomorphological mapping upto Cadastral level, by using high resolution satellite data in Gokaphaslwada watershed, DoulthabadMandal, Mahabubnagar District. IOSR Journal of Applied Geology and Geophysics, 5(1), 46-51. https://www.iosrjournals.org/iosr-jagg/papers/Vol.%205%20 Issue%201/Version-2/D0501024651.pdf
[14] Kumar, M.G., Agarwal, A.K., & Bali, R. (2008) Delineation of potential sites for water harvesting structures using remote sensing and GIS. Journal of the Indian Society of Remote Sensing, 36, 323–334. https:// doi/10.1007/s12524-008-0033-z.
[15] Lerner, D.N., & Harris, B. (2009). The relationship between land use and groundwater resources and quality. Land Use Policy, 26:265–273. https://doi.org/10.1016/j.landusepol.2009.09.005
[16] Madhnure, P., Gandrathi, P.K., kumar, R.G., Reddy, G.R.C., Rao, P.N., & Rao, A.D. (2016, April). Aquifer mapping for sustainable management of groundwater resources- A case study from fluorosis endemic areas of Nalgonda district, Telangana state [Paper presentation]. Conference India Water Week, New Delhi.
[17] Mati, B., De Bock, T., Malesu, M., Khaka, E., Oduor, A., Nyabenge, M., &Oduor, V. (2006). Mapping the potential of rainwater harvesting technologies in Africa: A GIS overview on development domains for the continent and ten selected countries. Technical Manual, 6,126. https://apps.worldagroforestry.org/downloads/Publications/PDFS/MN15297.pdf
[18] Potential Zones Using Weighted Overlay Technique for the Discernment of Site Suitable Artificial
[19] Prathap, T. S., Asiya, S., Ali, M. A., & Kamraju, M. (2019). Enumeration of Springs in Buggavanka Watershed, Kadapa, Andhra Pradesh, India. International Journal of Innovative Knowledge Concepts, 7(5).
[20] Prathap, T. S., Tej, K., & Ali, M. A. A GEOTECHNICAL STUDY OF SALT AFFECTED AREAS IN YOGI VEMANA UNIVERSITY WATERSHED AREA.
[21] Prathap, T. S., Yamini, Y., Ali, M. A., & Kamraju, M. (2019). CHANGE DETECTION IN LAND USE LAND COVER USING GEOSPATIAL TECHNOLOGY AND OPENSOURCE DATA IN LANKAMALLA FOREST AND THE NEIGHBOURHOOD–A CASE STUDY IN ANDHRA PRADESH.
[22] Recharge Structures in the Development of Avunoor Watershed. In R.K. Mishra, R.B. Singh & A.
[23] Sander. (2007). Lineaments in groundwater exploration: a review of applications and limitations. Hydrogeology Journal 15, 71–74. https://doi.org/10.1007/s10040-006-0138-9
[24] Scanlon, B.R., Reedy, R.C., Stonestrom, D.A., Prudic, D.E., &Dennehy, K.F. (2005). Impact of land use and land cover change on groundwater recharge and quality in the southwestern USA. Global Change Biology, 11, 1577–1593. https://doi.org/10.1111/j.1365-2486.2005.01026.x
[25] Shankar, R.M.N., & Mohan, G. (2005). A GIS based hydrogeomorphic approach for identification of site-specific artificial-recharge techniques in the Deccan Volcanic Province. Journal of Earth System Science, 114, 505–514. https://doi/10.1007/BF02702026
[26] Springer Singapore
[27] Strahler, A. N. (1957). Quantitative analysis of watershed geomorphology. Eos, Transactions American Geophysical Union, 38(6), 913-920.
[28] Vani, M., & Kamraju, M. (2016). IMPACT OF URBANISATION ON LAKES: A Case Study of Hyderabad. Journal of Urban and Regional Studies VOL, 5(1).



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY