IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

A Study Of NDBI, NDWI And NDVI Of Mahanadi And Kharun River Catchment Using GIS

[1]Divya Nirmalkar, [1]Kriti Rajput, [1]Sujal Mika, [1]Ram Naresh Yadav, [2]Soumya Pandey
[1]B.Tech Student, [2]Assistant Professor

[1,2] Department of Civil Engineering, Kalinga University, Kotni, Atal Nagar, Naya Raipur, C.G, India,492101

Abstract: This study investigates the spatio-temporal changes in vegetation, water availability, and urbanization from 2020 to 2025 in the Mahanadii and Kharun River region near Nava Raipur, Chhattisgarh, using remote sensing indices—NDVI (Normalized Difference Vegetation Index), NDWI (Normalized Difference Water Index), and NDBI (Normalized Difference Built-up Index). Results indicate a marginal rise in NDVI values for dense vegetation; however, a concurrent reduction in its spatial extent suggests ecological degradation and declining vegetation health. NDWI values exhibit a notable increase, linked to erratic climatic events such as off-season cyclonic rainfall, temporarily enhancing surface moisture but signaling rising climate volatility. NDBI analysis reveals significant urban expansion, reflecting conversion of natural and agricultural lands into built-up areas, contributing to urban heat island effects and hydrological disruption. These land use and land cover (LULC) changes pose serious environmental challenges including habitat loss, rising land surface temperatures, and reduced groundwater recharge. The findings underscore the urgent need for sustainable land management, preservation of riparian buffers, and climate-resilient urban planning to mitigate the adverse impacts of unregulated development and climatic instability in the region.

Index Terms **- Mahanadi River, Kharun River, GIS, NDVI, NDWI, NDBI**

Introduction

The Mahanadi River and its tributary, the Kharun, serve as lifelines for the states of Odisha and Chhattisgarh, supporting agriculture, industry, and the livelihoods of millions. However, these river systems are increasingly stressed due to anthropogenic pressures, climatic variability, and contested interstate water governance. The ongoing water dispute between Odisha and Chhattisgarh, which began more than eight years ago, illustrates the complex and politicized nature of water sharing in India. Rooted in the diversion of water for industrial purposes, the conflict has led to reduced water availability in Odisha, adversely affecting agriculture and drinking water supply [1-2]

The Mahanadi River basin spans approximately 141,589 km², accounting for around 4.3% of India's geographical area (India-WRIS, 2016). Following the creation of Chhattisgarh in 2000, both states pursued rapid industrialization, promoting the Mahanadi as a water-surplus river to attract investment. Consequently, significant volumes of river water have been diverted to coal mines, thermal power plants, and other industrial units, often at the cost of environmental sustainability and equitable resource distribution. The construction of barrages by Chhattisgarh to manage floodwaters has been strongly opposed by Odisha, which argues that these projects disrupt natural flow regimes and impact downstream communities [1]. Although both governments assert that their actions serve the interests of farmers, in practice, the majority of water consumption in both states is industrial [2].

The Kharun River, a key tributary of the Shivnath River and part of the larger Mahanadi river system [3], flows for approximately 147.53 km through Chhattisgarh, including some of its most densely populated and industrialized areas. The river plays a critical role in the region's socio-economic life, with numerous villages relying on its waters for irrigation, drinking, and domestic use [4]. However, the Kharun is also under severe environmental stress due to its proximity to urban and industrial zones. A satellite image analysis using Google Earth indicates a 14.82 km stretch of potential heavy metal contamination originating from the Bhilai Steel Plant, where industrial effluents likely reach the river through drainage and canal systems [4]. The discharge of urban, agricultural, and industrial waste into the Kharun River has significantly degraded its water quality [5].

Spectral indices are valuable tools for analyzing, interpreting, and forecasting surface processes. These indices are formulated using various combinations of satellite spectral bands and have been widely applied across diverse fields such as agriculture, water resource management, urban planning, forest ecology, geology, soil science, km and catchment of and vegetation studies[6]. This study addresses this gap by employing a criteria-based approach to assess both spectral and spatial consistencies. In this context, the use of remote sensing and GIS becomes essential to assess the evolving patterns of land and water use across the Mahanadi and Kharun catchments. This study applies three well-established indices — the Normalized Difference Built-up Index (NDBI), Normalized Difference Water Index (NDWI), and Normalized Difference Vegetation Index (NDVI) — to detect and map spatial and temporal changes in urban expansion, surface water availability, and vegetation health. These indices are crucial for understanding the extent of anthropogenic pressure on natural resources and for guiding evidence-based watershed management and policy interventions.

I. TYPE STYLE AND FONTS

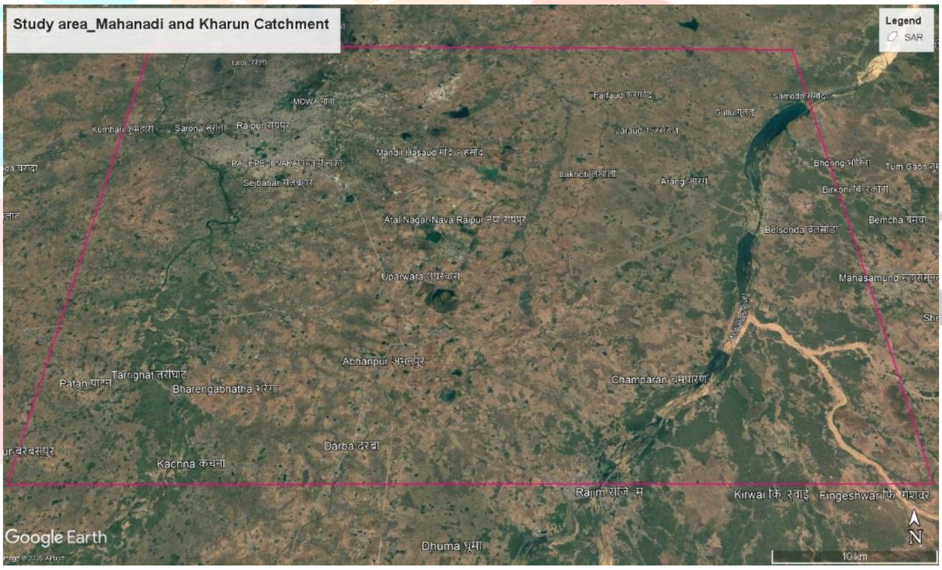

Figure 1: Study Area

The selected study area spans approximately 198 km, encompassing a catchment area of 2,377 km², situated between the Kharun and Mahanadi Rivers. This region includes the Atal Nagar area within the Nava Raipur zone, which forms a part of Raipur, the capital city of Chhattisgarh. The catchment is significant due to its role in supplying water for both agricultural activities and the expanding urban settlements. Nava Raipur is emerging as a rapidly developing suburban hub, hosting a range of newly established industries, commercial institutions, and key government establishments, including the Mantralaya. Given this dynamic land use transformation and growing pressure on water resources, monitoring land surface changes through spectral indices is of critical importance for sustainable planning and resource management.

II. MATERIAL AND METHODOLOGY

3.1 Data collection

Landsat 8, launched by NASA and the USGS, provides high-quality multispectral data suitable for monitoring various land surface features. The satellite carries the **Operational Land Imager (OLI)** sensor, which captures data across multiple spectral bands. Three key indices—**NDVI**, **NDWI**, and **NDBI**—were used in this study to assess vegetation health, surface water presence, and urbanization, respectively.

The data was collected from LANDSAT 8 OLI/TIRS level 2 collection 2 for the path 142 and row 045. The date for collected data in 2020 was 18-04-2020 and for year 2025 was 25-04-2025. The data was collected for 5-year gap to analyze the change in land feature for 5 year period.

3.2 Normalized Difference Vegetation Index (NDVI)

The **NDVI** is one of the most widely used vegetation indices that quantifies the presence and condition of green vegetation. It exploits the difference in reflectance between the **red** and **near-infrared (NIR)** bands. Healthy vegetation reflects more NIR and less red light, while non-vegetated surfaces do not show this contrast [2-3].

$$. NDVI=(NIR+Red)/(NIR-Red) \qquad (1)$$

Where:

- NIR = Band 5 (0.85 – 0.88 µm)
- Red = Band 4 (0.64 – 0.67 µm)

Interpretation:

- NDVI > 0.5 indicates dense vegetation
- NDVI ~ 0 suggests barren land or built-up
- NDVI < 0 indicates water or non-vegetated features

3.3 Normalized Difference Water Index (NDWI)

The **NDWI** is used to delineate open water features and suppress vegetation and soil noise. It utilizes the green and near-infrared bands[4-5]. The presence of water bodies is enhanced by high reflectance in the green band and low reflectance in the NIR band

$$NDWI=(Green+NIR)/(Green-NIR) \qquad (2)$$

Where:

- Green = Band 3 (0.53 – 0.59 µm)
- NIR = Band 5 (0.85 – 0.88 µm)

Interpretation:

- NDWI > 0 indicates water features
- NDWI < 0 generally corresponds to vegetation, soil, or built-up areas

3.2 Normalized Difference Built-up Index (NDBI)

The **NDBI** is used to identify built-up or urban areas. It compares the reflectance of the **shortwave infrared (SWIR)** and **near-infrared (NIR)** bands. Built-up areas tend to reflect more in SWIR than in NIR, enabling their clear identification [5-6].

$$NDBI=(SWIR+NIR)/(SWIR-NIR) \qquad (3)$$

Where:

- SWIR = Band 6 (1.57 – 1.65 µm)
- NIR = Band 5 (0.85 – 0.88 µm)

Interpretation:

- NDBI > 0 indicates built-up/urban areas
- NDBI < 0 typically corresponds to water, vegetation, or bare land

These indices help in classifying and analyzing the spatial distribution of vegetation cover, urban growth, and water bodies, thus providing insights into the environmental impact of rapid urbanization and industrial activities in the Kharun and Mahanadi river catchments.

IV. RESULTS AND DISCUSSION

4.1 Results of NDVI

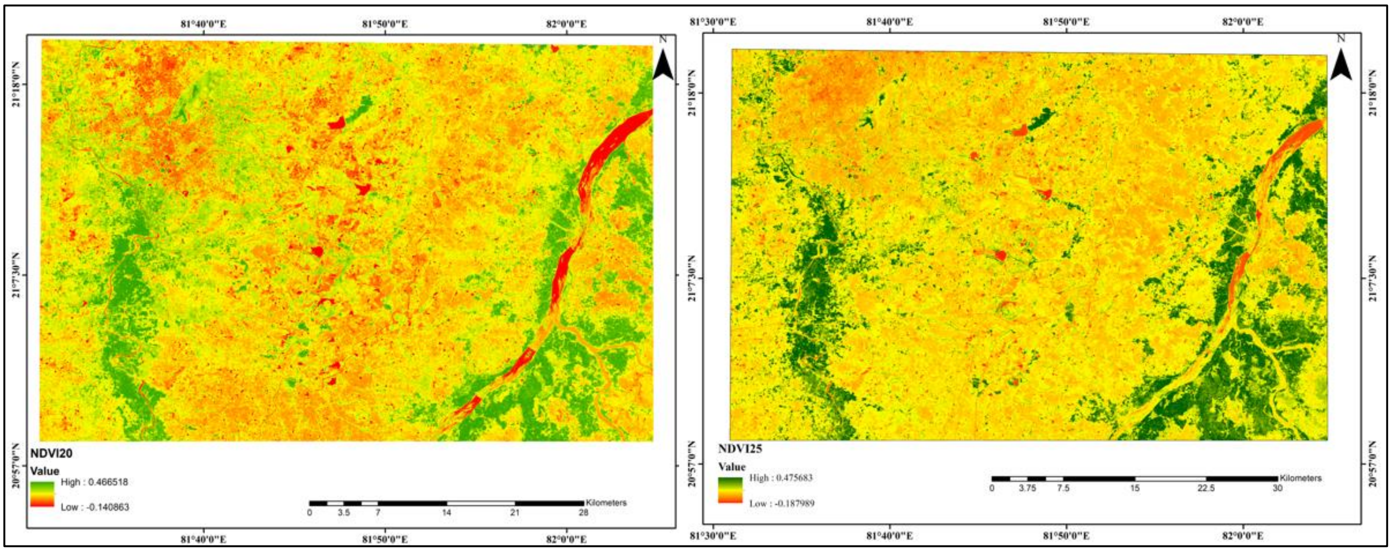

Figure 2: Change in NDVI of the study area for 5 year period

The figure 2 demonstrates a notable change in Normalized Difference Vegetation Index (NDVI) values over the period from 2020 to 2025 for the study area encompassing the Mahandai and Kharun River regions near Nava Raipur, Chhattisgarh. Specifically, the NDVI value for dense vegetation has slightly shifted from 0.466 in 2020 to 0.475 in 2025. Although this numeric change appears minor, the decrease in the relative coverage of healthy dense vegetation is an alarming environmental signal.

The decline in healthy vegetation adversely affects multiple ecological parameters. Vegetation acts as a critical regulator of local microclimate, supporting temperature moderation, surface water flow management, prevention of soil erosion, and serving as habitats and migration corridors for wildlife. A reduction in dense vegetation directly contributes to rising land surface temperatures (LST) and disrupts the natural hydrological cycles by altering infiltration rates and runoff volumes . Furthermore, loss of vegetation near riparian zones, such as those around the Mahandai and Kharun Rivers, can significantly degrade water quality, increasing sediment load and nutrient runoff.

Interestingly, sparse vegetation coverage has increased between 2020 and 2025. However, much of this sparse vegetation is associated with agricultural practices, often characterized by seasonal crop rotations, weed proliferation, and short-lived biomass rather than permanent native vegetation. The region's dominance by agricultural lands, coupled with susceptibility to weed growth and changing crop patterns, introduces temporal variability into NDVI values. Studies have shown that cropland areas can generate misleadingly high NDVI values during peak growth seasons but do not offer the same long-term ecological stability as natural vegetation.

Specifically for Chhattisgarh, several studies have confirmed the vulnerability of river-adjacent ecosystems to land use/land cover (LULC) changes due to rapid urbanization near Nava Raipur. As urban expansion moves closer to sensitive river systems like Mahandai and Kharun, the loss of green cover threatens not only regional biodiversity but also human water security and climate resilience.

Thus, the observed NDVI changes underscore the urgent need for sustainable land management practices, riparian buffer zone protection, and strategic urban green space planning to mitigate the escalating environmental risks in this rapidly transforming peri-urban landscape.

4.2 Results of NDWI

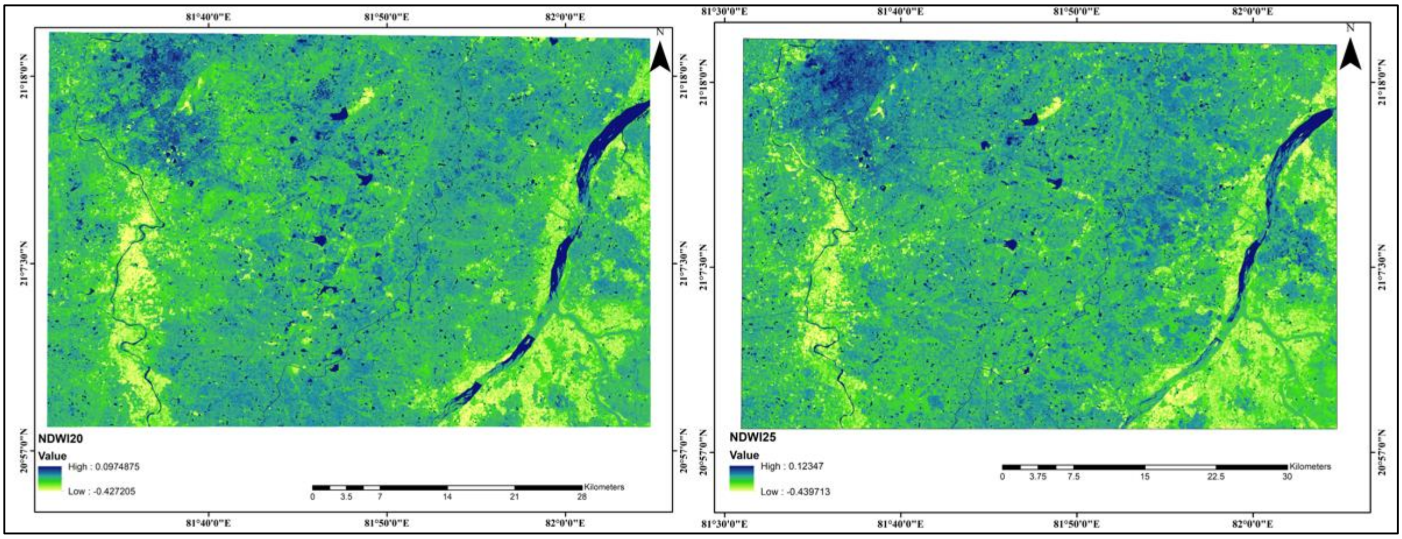

Figure 3: Change in NDWI of the study area for 5 year period

The analysis of Normalized Difference Water Index (NDWI) over the Mahandai and Kharun River region near Nava Raipur indicates a notable increase between 2020 and 2025. The NDWI value rose from 0.097 in 2020 to 0.1235 in 2025. NDWI is a crucial remote sensing-derived indicator, primarily sensitive to changes in surface water presence and moisture conditions (Figure 3). It uses the reflectance difference between the Near-Infrared (NIR) and Shortwave Infrared (SWIR) bands to detect water bodies and soil moisture content across landscapes[8-9].

An increase in NDWI typically reflects higher surface water content, which could stem from enhanced water retention, new surface water bodies, or seasonal moisture accumulation. In this case, the observed rise aligns with recent climatic variability affecting the region. Chhattisgarh, including areas around Nava Raipur, has been witnessing erratic climatic behaviour over the past few years, largely influenced by anomalous monsoon activities and off-season cyclonic events.

Specifically, February and March—traditionally part of the dry pre-monsoon season—have experienced uncharacteristic rainfall events, largely driven by cyclones forming in the Bay of Bengal and making landfall with extensive inland penetration. Such unexpected rainfall not only temporarily increases the surface water content but also modifies groundwater recharge patterns, soil moisture regimes, and riparian habitat structures. However, it is important to interpret the increased NDWI with caution. Although short-term gains in surface moisture can be beneficial, the long-term trend of climatic irregularity poses significant risks for agriculture, riverine ecosystems, and urban planning. The rising climate volatility in eastern-central India, including Chhattisgarh, underscores the need for adaptive water resource management and resilient land-use planning to cope with flash floods, soil saturation, and potential waterlogging challenges.

Thus, while the higher NDWI in 2025 signifies a temporary boost in surface moisture, it is symptomatic of broader climatic instability that demands urgent attention from environmental planners, policymakers, and disaster management authorities in the region.

. 4.3 Results of NDBI

The figure 4 presented illustrates the Normalized Difference Built-up Index (NDBI) change between 2020 and 2025 across the study region. The NDBI is a well-established spectral index utilized in remote sensing to detect built-up land features by leveraging the reflectance differences between the Near Infrared (NIR) and Shortwave Infrared (SWIR) bands. An increase in NDBI values typically correlates with an expansion of impervious surfaces such as concrete, asphalt, and other urban infrastructure [7,10].

From the figures, it is evident that there is a positive shift in NDBI values from 0.414 in 2020 to 0.457 in 2025. This rise signifies a marked increase in urbanized areas and expansion over previously fallow or open lands. The increasing NDBI trend suggests not only the growth of urban settlements but also likely conversions of agricultural lands, wastelands, or open fields into built-up zones.

In the specific context of Chhattisgarh, the state has been increasingly susceptible to extreme thermal stress and vegetation degradation during the analyzed period. The combination of intensified urbanization and reduction in vegetative cover aggravates the region's exposure to urban heat island (UHI) effects. Loss of vegetation diminishes the land's natural cooling ability through processes like evapotranspiration, thereby increasing the land surface temperature (LST). Additionally, soil sealing from new constructions prevents natural infiltration, affecting groundwater recharge and further stressing the local environment.

The changing land use-land cover (LULC) patterns observed are consistent with broader environmental challenges facing Chhattisgarh, including rising average temperatures, increased frequency of heatwaves, and a decline in ecosystem services. Monitoring NDBI trends thus provides critical insights for urban planners and policymakers to devise sustainable urban development strategies and mitigation measures against environmental degradation

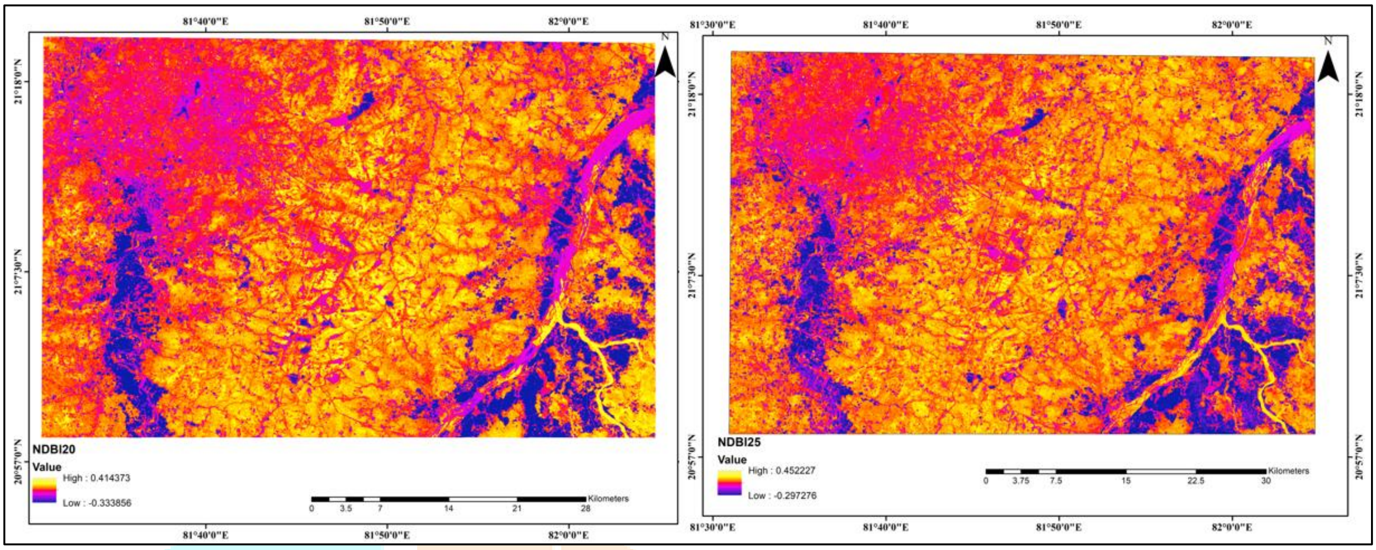

Figure 4: Change in NDBI of the study area for 5 year period

V. CONCLUSION

The analysis of NDVI, NDWI, and NDBI over the Mahandai and Kharun River region near Nava Raipur, Chhattisgarh, from 2020 to 2025 reveals significant and interconnected environmental transformations. The slight increase in NDVI for dense vegetation masks a worrying trend: a decrease in healthy vegetative coverage, largely replaced by sparse, agriculture-linked greenery, which lacks the long-term ecological stability of native flora. Simultaneously, the NDWI has shown a moderate rise, likely influenced by unusual climatic events such as off-season rainfall and cyclonic activity. While temporarily beneficial in terms of surface moisture, these fluctuations signal broader climatic volatility that threatens agricultural and hydrological stability.

Most notably, the increase in NDBI values confirms rapid urban expansion, leading to intensified land surface temperatures and diminished natural vegetation. These LULC changes collectively point to escalating anthropogenic pressure on peri-urban ecosystems, reduction in natural buffers, and weakening of climate resilience. If these trends continue unchecked, the region may face serious challenges, including loss of biodiversity, increased urban flooding, and water insecurity.

Thus, the findings emphasize the urgent need for integrated land-use planning that balances development with ecological sustainability. Policies promoting riparian buffer zones, conservation of dense vegetation, and adaptive urban design must be prioritized to safeguard environmental integrity and enhance resilience against the growing impacts of climate change and urbanization.

REFERENCES

[1] Kshetri, T., 2018. Ndvi, ndbi & ndwi calculation using landsat 7, 8. *GeoWorld*, *2*, pp.32-34.

[2] Zheng, Y., Tang, L. and Wang, H., 2021. An improved approach for monitoring urban built-up areas by combining NPP-VIIRS nighttime light, NDVI, NDWI, and NDBI. *Journal of cleaner production*, *328*, p.129488.

[3] Pattanayak, S.P. and Diwakar, S.K., 2018. Seasonal comparative study of NDVI, NDBI and NDWI of Hyderabad City (Telangana) based on LISS-III image using remote sensing and DIP. *Khoj: An International Peer Reviewed Journal of Geography*, *5*(1), pp.78-86.

[4] Bala, R., Prasad, R., Yadav, V.P. and Sharma, J., 2018. A comparative study of land surface temperature with different indices on heterogeneous land cover using Landsat 8 data. *The international archives of the photogrammetry, remote sensing and spatial information sciences*, *42*, pp.389-394.

[5] Shah, S.A., Kiran, M., Nazir, A. and Ashrafani, S.H., 2022. Exploring NDVI and NDBI relationship using Landsat 8 OLI/TIRS in Khangarh taluka, Ghotki. *Malaysian Journal of Geosciences*, *6*(1), pp.08-11.

[6] Prasomsup, W., Piyatadsananon, P., Aunphoklang, W. and Boonrang, A., 2020. Extraction technic for built-up area classification in Landsat 8 imagery. *International Journal of Environmental Science and Development*, *11*(1), pp.15-20.

[7] Bhatti, S.S. and Tripathi, N.K., 2014. Built-up area extraction using Landsat 8 OLI imagery. *GIScience & remote sensing*, *51*(4), pp.445-467.

[8] Taufik, A. and Ahmad, S.S.S., 2016, June. Land cover classification of Landsat 8 satellite data based on Fuzzy Logic approach. In *IOP Conference Series: Earth and Environmental Science* (Vol. 37, No. 1, p. 012062). IOP Publishing.

[9] Nikkala, S., Peddada, J.R. and Neredimelli, R., 2022. Correlation analysis of land surface temperature on landsat-8 data of Visakhapatnam Urban Area, Andhra Pradesh, India. *Earth Science Informatics*, *15*(3), pp.1963-1975.

[10] Alademomi, A.S., Okolie, C.J., Daramola, O.E., Akinnusi, S.A., Adediran, E., Olanrewaju, H.O., Alabi, A.O., Salami, T.J. and Odumosu, J., 2022. The interrelationship between LST, NDVI, NDBI, and land cover change in a section of Lagos metropolis, Nigeria. *Applied Geomatics*, *14*(2), pp.299-314.