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Geospatial Analysis of LULC Changes and NDVI-Based Vegetation Patterns in the Kang Basin area of Jalgaon Dist (MH)

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Abstract
"India's agricultural sector is the foundation of the nation. At present, agriculture engages 50% of the population of India and contributes to 18.3% of the country's GDP. (The 2024–25 Economic Survey). Based on the agricultural sector's historical contribution to India's GDP, the country is currently leading in this area. At present, modern technology is being used to produce high-quality goods on a huge scale, and the agricultural sector has played a significant role in India's sustainable development. The most significant changes in the studied area have occurred in the forest area. The main reason for this change is that 1200 hectares of this forest area were protected, resulting in a change in the vegetation index. The changes in the area were shown over two decades (2015-2025) while studying LULC and NDVI. Due to the dam constructed in this research area, there have been changes in the agricultural area, and the groundwater level has also increased compared to 2015. The irrigation system has changed, and significant improvements in water conserving output, crop variety, and cropping patterns have all been seen. Primarily, this study uses geospatial techniques to show the changes in LULC and NDVI over two decades. Using a comparative and assessment study, the current study has demonstrated the effects of the kang irrigation project on the agricultural sector using geospatial techniques. According to the study's conclusion, cropping patterns and irrigation techniques have changed, and agricultural capacity has significantly expanded in this sector."

Keywords: *Geospatial technique, Kang project, Irrigation, LULC & NDVI.*

Introduction

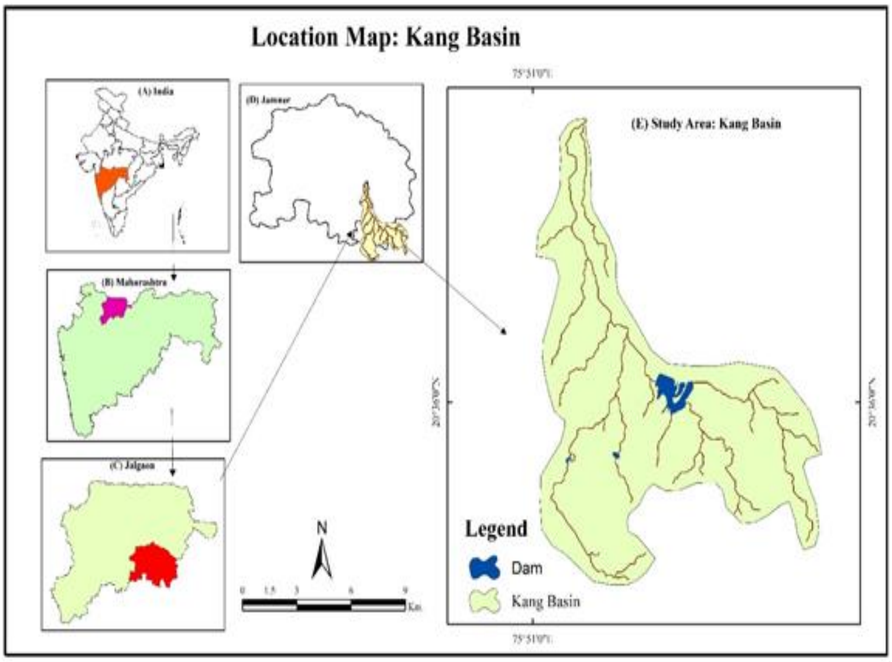
In India, irrigation is one of the most dominant inputs for agricultural production because agriculture is dependent on water availability. In order to ensure food security, irrigation projects have become essential due to the expanding population and unpredictable monsoon patterns. An important factor in raising crop production and the availability of food is agricultural land. Global ecological concerns and increased competition in markets have recently raised awareness of traditional agricultural practices. Accordingly, there has been a growing need for more effective irrigation techniques and more economical use of the water resources that are available. Thus, the use of modern technologies such as GIS and remote sensing is essential for managing irrigation networks and ensuring proper use of irrigation for sustainable agriculture. Sub-Saharan Africa's semi-arid regions were the primary goal of the development of the GIS-based comprehensive model for evaluating irrigation potential (Moeti,2005; You et al.,2010). Using geospatial techniques, it shows cropping assessment in two sections: agricultural potential and agricultural rabi (Vidya K., Sanjukta C, T.P. Singh 2013). Jamner tehsil is one of the important tehsils in Jalgaon district having various types of agricultural sector. During the last few years, transformations have occurred in agriculture sector land use hence it becomes essential to study those changes. Therefore, the topic undertaken for the present study has its significance for planning and development. The Kang Irrigation Project was started in Jalgaon District, Maharashtra, to distribute surface water and increase agricultural output in semi-arid areas.

Remote Sensing (RS) and Geographic Information Systems (GIS) are integrated and accurate instruments for observing and evaluating spatial and temporal changes in cropping patterns and agricultural land use over time. The core purpose of this study is to employ satellite-based geospatial approaches to examine the spatial and temporal effects of the Kang Irrigation Project on the status of agricultural land and vegetation in the command area. The Kang Irrigation Project, situated in the Jalgaon District, Maharashtra (MH), is a minor project that constitutes an important component of the Kang River's water resource management. The present study specifically focuses on assessing and quantifying the changes in agricultural potential within the project's service area, which spans 132.92 sq. km.

Shirpur City is the biggest industrial and commercial centre of Shirpur tehsil. The high economic growth, education facilities and employment opportunities caused influx of labour immigration. According to demographic survey of 11 Oct. 2010, Shirpur City had 14 thousand immigrants in the population total of 76905. Local increase of population plus immigrants made the city become too stuffy. According to statistics, the urban population has increased 73.81% from 1991 to 2011. (Yogesh Mahajan et. al)

Study Area

The Kang Basin within the Jamner Tehsil of the Jalgaon District, Maharashtra, serves as the focus for this research. Geographically, the basin spans longitudes from 75^{0} 50' 0" east to 76^{0} 00' 0" east and latitudes from 20^{0} 30' 0" north to 20^{0} 40' 0" north. This study area, the Kang Basin, occupies 132.92 sq.km of the tehsil, which itself is located in the south-east of the Jalgaon district. The wider Jamner Tehsil covers 1308.94 sq.km and, as per the 2011 census, supported a population of 349957, with the majority (303195) residing in rural areas. The region is bordered by Jalgaon Tehsil to the north-west, Buldhana District to the east, Jalna District to the south-east, Chatrapati Sambhajinagar District to the south, and Pachora Tehsil to the west. Topographically, the Fattepur Circle in the south connects to the Ajanta-Satmala range. Hydrologically, the tehsil receives a slightly above-average annual rainfall of approximately 750 - 802 mm. Crucially, the presence of three minor irrigation projects in the basin significantly benefits the agricultural sector by ensuring water availability to villages like Godri, Fattepur, Kinhi, Ravala, and Takli. The tehsil is administratively segmented into 8 blocks/circles and encompasses 159 villages.



Objective:

- ❖ To assess the land use/land cover changes before and after the implementation of the Kang irrigation project.
- ❖ To analyse changes in vegetation using the Normalized Difference Vegetation Index (NDVI)

Data Methodology:

- **Toposheet no-46O/12**

The method has been selected to achieve the objective of the study after an assessment of the collection of current research.

1. **Primary Data/ Field work:**

A survey, a specially designed questionnaire and information collected from farmers were used to collect primary data. Data collection involved several field visits. Interviews were conducted to collect information, which was then used for statistical analysis and interpretation.

2. **Secondary Data:**

The secondary data was collected from a multitude of sources, including the Agriculture Department, Forest Department, Talathi offices, Survey of India, Census of India, Jalgaon district statistical reports, socio-economic assessments, etc.

Landsat Image	Sensor	Date of acquisition	Path/ Row	No. of bands	Resolution	Sources
Landsat 7	ETM+	17/04/2015	146/46	8	30	USGS
Landsat 8	ETM+	15/02/2025	146/46	9	30	

3. **Laboratory Work:**

a) **Data Processing:** Area calculation, georeferencing, merging, digitizing various layers, making maps, and change detection analysis were all included in the data processing.

b) **Examining the Toposheets:** The study's topographical map was supplied by the Survey of India. area. These Toposheets will be scanned and stored in jpeg format to digitize them while helping more analysis.

c) **Georeferencing the Toposheets:** After scanned Toposheets have been filled into ArcGIS, Quantum Geographic Information System (QGIS) for georeferencing, satellite pictures will be georeferenced.

Process of the Drainage map and LULC map

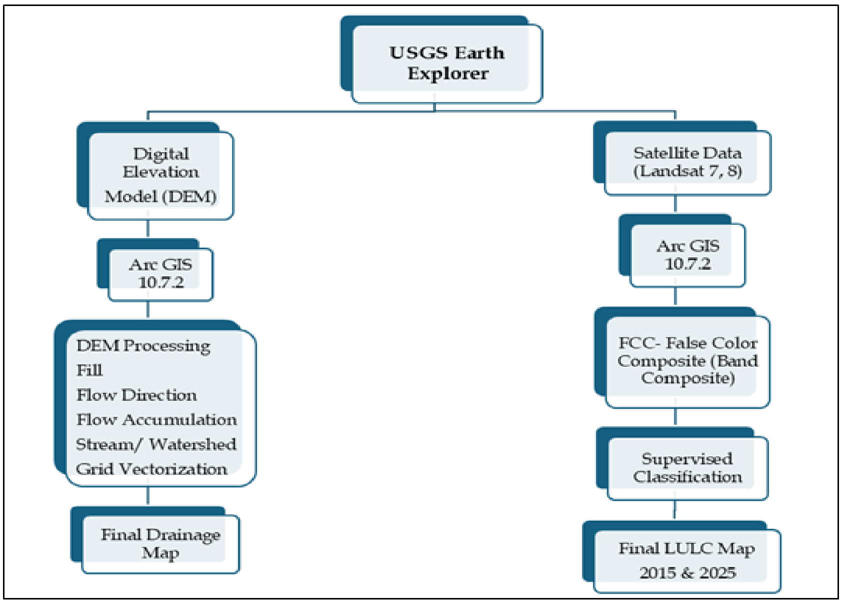


Fig.2 Source: USGS Earth Explorer Website

Results and Discussions:

"Land Use/Land Cover (LULC) change detection is a critical process, as it helps researchers understand "what is changing, why it is changing, and what impacts those changes have" on the environment, society, and economy. This analysis provides essential context for sustainable development and resource management.

In the context of this research area (the Kang Basin), changes in LULC were analyze across a specific time frame—over the past two decades—using maps and charts derived from geospatial data. The study focused on assessing and quantifying shifts among the following key LULC categories: Agriculture, Barren Land, Built-up Land, Forest, Rivers, Water Bodies.

This analysis is instrumental in linking the influence of the Kang Irrigation Project to the resulting spatial and temporal transformations in the landscape."

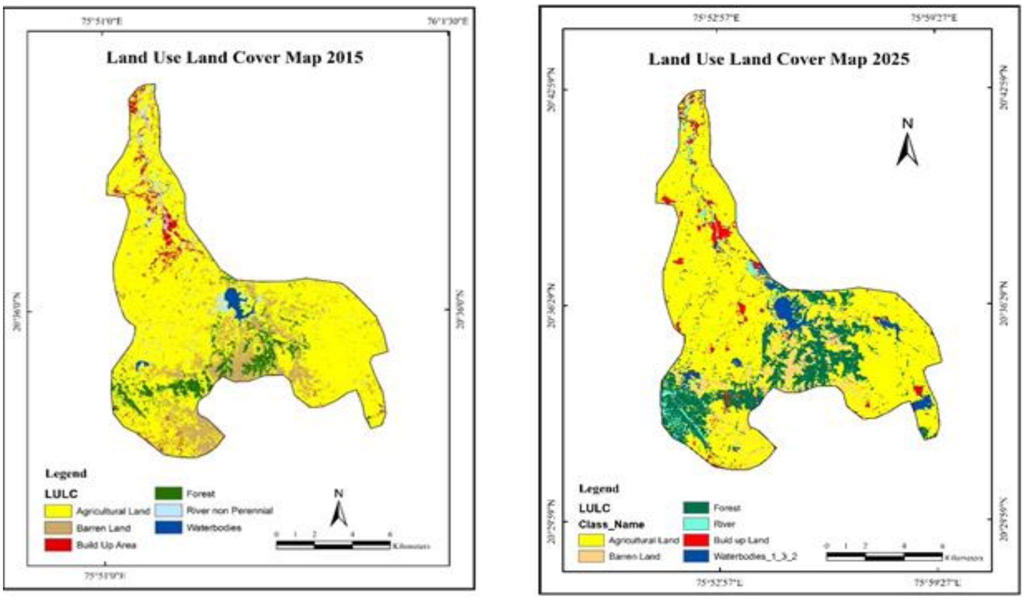


Fig. 3. Land Use / Land Cover map of Kang Basin 2015 and 2025

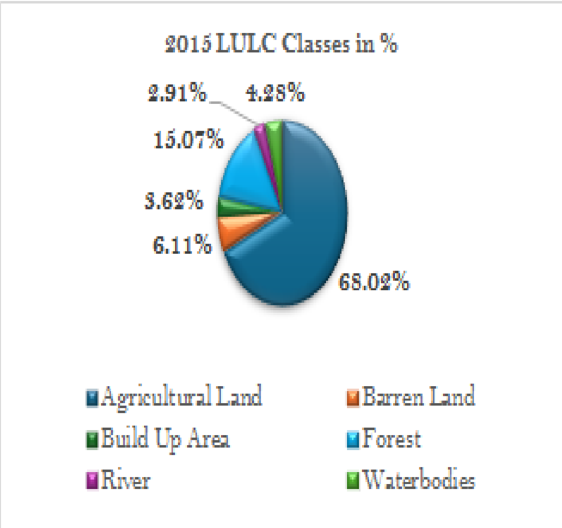
In 2015, the Kang Basin was characterized by a landscape predominantly defined by agrarian use, with agricultural land serving as the primary land cover category. During this period, forest cover remained limited and highly fragmented, restricted mostly to the southern and south-western reaches. A significant portion of the basin was classified as barren land, particularly in upland and marginal zones, which pointed toward widespread land degradation or extensive fallow periods. Furthermore, surface water resources were localized and sparse, and built-up areas remained minimal, consisting primarily of scattered rural settlements.

By 2025, the basin underwent a notable transformation, marked by a significant increase in both forest density and agricultural continuity. The reduction in barren land suggests a successful conversion of degraded soils into productive agricultural or vegetated zones, likely spurred by improved land management practices. This decade also saw a measurable expansion in forest cover across the southern, central, and eastern regions, indicating successful afforestation or natural regeneration efforts. Concurrently, water bodies and river features became more clearly defined and slightly expanded, potentially reflecting the impact of watershed development and conservation initiatives.

These shifts highlight a positive trend in the Kang Basin's ecological and productive capacity. However, the gradual expansion of built-up areas and infrastructure—driven by population growth—presents a new set of challenges. While the overall increase in vegetation and water availability enhances environmental stability, the growing human footprint necessitates a balanced approach to basin-level planning. To ensure long-term resilience, future management must harmonize agricultural and urban development with the continued conservation of the basin's natural resources.

Land Use Land Cover Classes	2015		2025		Actual Changes	
	Sq. km	%	Sq. km	%	Sq. km	%
Agricultural Land	94.83	71.34%	90.41	68.02%	-4.42	-3.33
Barren Land	16.8	12.64%	8.12	6.11%	-6.68	-5.03
Build Up Area	3.29	2.48%	4.81	3.62%	1.52	1.14
Forest	10.15	7.64%	20.03	15.07%	9.88	7.43
River	4.3	3.24%	3.87	2.91%	-0.43	-0.32
Waterbodies	3.55	2.67%	5.69	4.28%	2.14	1.61
Grand Total	**132.92**	**100%**	**132.92**	**100%**		

Table 2. Geographical distribution of land use/ land cover classified from 2015 to 2025



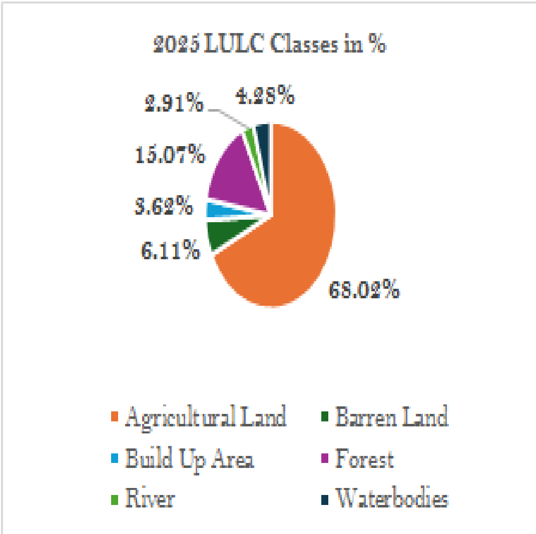


Fig. 4. General landuse pie chart 2015 and 2025

The land use land cover map classification for 2015 shows that the Agricultural Dominance is a significant majority (71.34%) of the study area, equivalent to 94.83 sq. km, is dedicated to agricultural activities, indicating the area's strong agricultural focus. Barren land is notable portion (12.64%) of the area, or 16.8 sq. km, is classified as barren land, suggesting potential for development or reclamation. Built-up areas occupy a relatively small percentage (2.48%) of the study area, covering 3.29 sq. km, indicating limited urban development. Natural Resources such as a Forests cover 7.64% (10.15 sq. km), while waterbodies and non-perennial rivers account for 2.67% (3.55 sq. km) and 3.24% (4.3 sq. km), respectively, highlighting the area's natural resources.

The land use land cover map categorization for 2025 indicates that the Agricultural land continues to dominate the study area, covering 68.02% (90.41 sq. km) of the total area, showing a strong agricultural focus. Barren land accounts for 6.11% (8.12 sq. km) of the region, suggesting possibility for development or rehabilitation.

Only 3.62% of the study area, or 4.81 sq. km., is made up of built-up regions, showing little urban development. Forests represent 15.07% (20.03 sq. km) of the area's natural resources, while waterbodies and non-perennial rivers make up 4.28% (5.69 sq. km) and 2.91% (3.87 sq. km), respectively.

A comparative study of the decade 2015 and 2025 shows that there has been a decrease in the areas of agriculture (-3.33%), barren land (-5.03%), and rivers (-0.32%) compared to 2015, while there has been a significant change in the areas of built-up land (1.14%), forests (7.43%), and waterbodies (1.61%) and an increase in the areas compared to 2015. The LULC maps of 2015 and 2025 reveal significant transformations in land use patterns within the study area over the ten-year period. These changes reflect the combined influence of agricultural practices, expansion of settlement and natural resource management such as forest, River, waterbodies.

Normalized difference vegetation index (NDVI) changes:

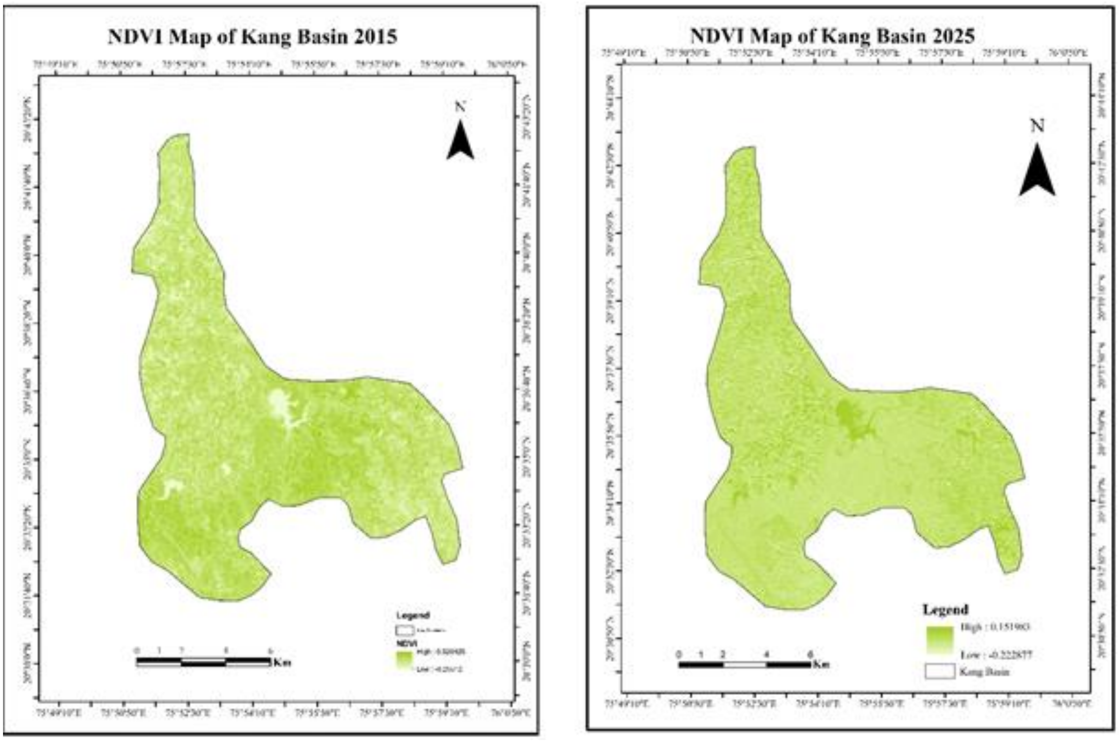


Fig. 5. Land Use / Land Cover map of Kang Basin 2015 and 2025

Assessment of Normalized difference vegetation index (NDVI)

The indicators that show natural changes in the land surface are used in the NDVI study. The visible and near-infrared sections of the electromagnetic spectrum are used to calculate the NDVI, a quantitative indicator of healthy green vegetation. The range of the NDVI value is -1 to 1. NDVI was applied in this study to explain vegetation changes. In this study, the Near Infrared and Red bands in (Band 4 - Band 3)/ (Band 4 + Band 3) in Landsat 7 and (Band 5 - Band 4)/ (Band 5+Band 4) in Landsat 8 were used.

$$\mathbf{NDVI} = \frac{\boldsymbol{NIR - Red}}{\boldsymbol{NIR + Red}}$$

The spectral characteristics of vegetation absorb light energy from plants through photosynthesis and reflect near-infrared radiation form the basis of the vegetation index. To identify watersheds, shrub regions, hilly areas, land cover categorization, dense forests, sparse forests, and agricultural areas, multispectral remote sensing data is analyzed using the NDVI and vegetation index.

In 2015, the study area's NDVI value range was -0.25 to +0.52, but by 2025, it changed to -0.22 to 0.15. The assessment of the NDVI research indicates the extent of vegetation change over the past two decades. Arc GIS 10.7 software was used to identify the vegetation cover. 2015 and 2025 showed the lowest and maximum NDVI concentrations respectively, with the majority of the values changing in 2025. Studying over the last two decades demonstrates that forests and vegetation can also be classified as productive due to high NDVI values, whereas NDVI values also indicate places that are barren, such as residential areas, water bodies, and land. The central part of the study area, especially the rural settlement area, shows low NDVI values, while the southern part and the surrounding waterbodies show high NDVI values. By calculating the vegetation index for land cover classification, land and resources can be perfectly defined. NDVI is very effective in identifying land cover, which is useful for analysis.

The spatio-temporal analysis of the Normalized Difference Vegetation Index (NDVI) within the Kang Basin reveals a significant positive trend in vegetation health and density over the decade spanning 2015 to 2025. In 2015, the basin was characterized by moderate and uneven NDVI values, dominated by light to medium green tones. This pattern suggested a landscape primarily reliant on rainfed agriculture and seasonal growth, marked by patchy variations and fallow lands that indicated potential land degradation or inconsistent crop vigor.

By 2025, the basin's ecological profile underwent a visible transformation, exhibiting higher and more uniform NDVI values. The reduction in low-NDVI patches and the transition of barren or fallow areas into vegetated zones point toward more continuous and healthier biomass across the region. This improvement is particularly concentrated in the central and southern sectors of the basin, signaling a shift toward intensified agriculture, enhanced moisture availability, and more robust land and water management practices.

Geographically, these shifts reflect enhanced biomass productivity and improved ecological stability, reducing the immediate risk of land degradation. However, the expansion and intensification of vegetation cover also imply a potential increase in regional water demand, especially if these gains are driven by irrigation-dependent agriculture. In conclusion, the comparative analysis highlights a period of successful agricultural expansion and improved land-use efficiency. These findings underscore the necessity of continuous monitoring to ensure that the increased resource consumption remains sustainable within the basin's long-term environmental capacity.

Conclusion

Due to the irrigation projects built in the Kang Valley, there have been significant changes in the agricultural sector in terms of cropping patterns, crop combinations, crop diversification, changes in irrigation methods, increased soil fertility, abundant water resources, various government schemes, etc. Due to these changes in agriculture, there has been an increase in the trend towards irrigated and horticulture agriculture.

The land use land cover map classification for 2015 and 2025 reveals a consistent dominance of agricultural land in the study area, although with a slight decrease from 71.34% (2015) to 68.02% (2025). The built-up area has shown a marginal increase from 2.48% (2015) to 3.62% (2025), indicating slow urban development. Notably, forest cover has increased from 7.64% (2015) to 15.07% (2025), highlighting conservation efforts. Barren land has decreased from 12.64% (2015) to 6.11% (2025), suggesting potential development or reclamation.

The integrated analysis of NDVI and LULC trends from 2015 to 2025 demonstrates a profound ecological and structural evolution of the Kang Basin. Over this decade, the basin transitioned from a fragmented landscape characterized by seasonal rainfed agriculture and significant barren patches into a more productive and stable environment. The simultaneous increase in vegetation density and forest cover, alongside the reduction of degraded lands, underscores the success of improved land management and watershed development initiatives. These changes have collectively enhanced the basin's biomass productivity and ecological resilience.

However, this positive transformation introduces a complex management paradox. While the expansion of agricultural continuity and forest regeneration strengthens the ecosystem, it also coincides with rising urbanization and a likely increase in water demand for irrigation. To maintain the gains achieved over the last decade, it is imperative that future resource management strategies adopt a holistic approach. Sustainable basin-level planning must prioritize the balance between intensifying human activities and the preservation of natural resources to ensure the Kang Basin remains a resilient and productive landscape for the future.

Overall, the study area remains predominantly agricultural, with a need for sustainable management of natural resources, balanced rural development, and continued conservation efforts to maintain ecological balance.

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Conflicts of interest
The authors declare that there are no conflicts of interest regarding the publication of this paper.

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