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Assessment of Land Use and Land Cover Changes in the Wainganga River Basin (Maharashtra) Using Multi-temporal Remote Sensing and GIS

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ABSTRACT

Land use and land cover (LULC) dynamics play a critical role in shaping hydrological processes, ecological stability, and socio-economic development within river basins. The Wainganga River Basin, a major tributary of the Godavari River system in eastern Maharashtra, has experienced notable land transformation due to agricultural expansion, population growth, and infrastructural development. The present study aims to assess and map the spatial distribution of land use and land cover at a micro-basin level using multi-temporal remote sensing data and Geographic Information System (GIS) techniques. Topographic maps from the Survey of India and satellite imagery were integrated within a GIS environment, and supervised classification methods were employed to generate LULC maps. A total of ten land use and land cover classes were identified, including dense forest, sparse vegetation, open scrub, agriculture, water bodies, barren land, fallow land, settlements, rocky/open spaces, and gravel land. The results indicate that forest cover dominates the basin, accounting for 65.75% of the total geographical area, reflecting the ecological significance of the region. Agricultural land constitutes 14.17% of the basin and remains the primary source of livelihood for the local population, while built-up land occupies only 1.89%, though it is spatially concentrated along river courses and fertile plains.

The study highlights the effectiveness of remote sensing and GIS in accurately mapping and analyzing LULC patterns in large river basins. The generated spatial database provides essential inputs for sustainable land use planning, watershed management, and environmental conservation. The findings serve as a scientific baseline for future monitoring of land use changes and support informed decision-making for balanced and sustainable development in the Wainganga River Basin.

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1. Introduction:

Land use and land cover inventories are essential for the optimal utilization and management of resources in a basin. Land use and land cover change detection are essential to understand the existing situation and plan for the future. Land use and land cover (LULC) represent the physical and biological cover of the Earth's surface and reflect the complex interactions between natural processes and human activities. Changes in LULC have significant implications for hydrological processes, biodiversity, soil stability, climate regulation, and overall watershed health. River basins, in particular, are highly sensitive to land transformation due to their dependence on surface runoff, groundwater recharge, and human utilization of water and land resources. The Wainganga River is one of the major tributaries of the Godavari River system and plays a crucial role in the socio-economic development of eastern Maharashtra. The basin supports extensive agricultural activities, forest ecosystems, and rapidly expanding settlements. In recent decades, the region has experienced notable changes due to population growth, agricultural intensification, infrastructure development, and deforestation. Several studies have demonstrated the effectiveness of remote sensing and GIS in LULC classification, change detection, and environmental assessment of river basins

In this paper an attempt has been made to analyze the general land use pattern at micro level in Wainganga river basin. The study seeks to generate accurate LULC maps, quantify changes over time, and provide valuable insights for sustainable land and water resource management, environmental conservation, and regional planning in the Wainganga River Basin. According to Longley(2001), "Land covers refer to the physical materials on the surface of a given parcel of land, while Land use refer to the human activities that take place on or make use of land for e.g. Residential, commercial, industrial etc." According to Iiayaraja (2012) an attempted has been made to classify the reflectance characteristics of remote sensing. This information not only provides a better understanding of land utilization aspects but also plays a vital role in development of any region. The present study will be useful for further planning and management for Wainganga river basin.

2. Study area:

The Wainganga River rises at El 640.0 m in the Seoni District of Madhya Pradesh from the Western slopes of Maikala Ranges which is continuation of the Satpura Ranges in Central India. The Wainganga river receives numerous tributaries on either bank and drains the western, central and eastern regions of the Chandrapur, Gadchiroli, Bhandara, Gondia and Nagpur districts of Maharashtra.

The total river basin area in Maharashtra – 26,347.01 Sq. km.

Latitude extension- $19^0$30'N to $22^0$30 N'

Longitude extension- $79^0$00'E to $80^0$30 E'

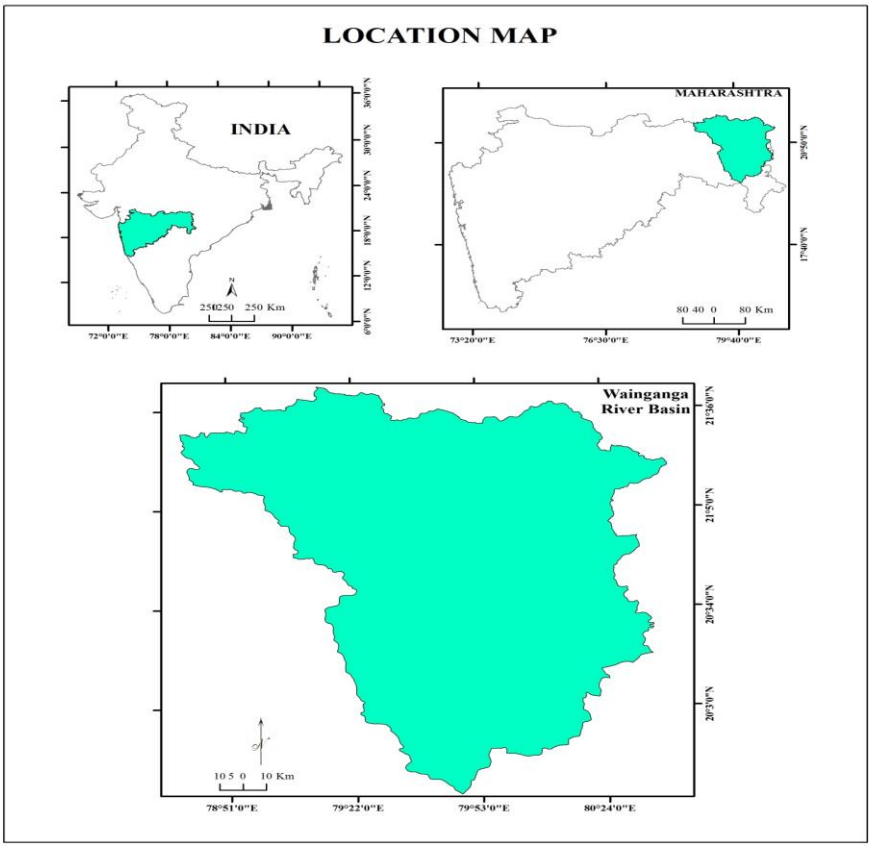

Figure 1 Wainganga River

The river in it's the initial reaches flow westwards and thereafter southwards in M.P. State and continues to flow Southwards in Maharashtra State. It is joined by the Wardha River at a place called Gundapet flowing from the west, draining the major portion of the Maharashtra Plateau. There after the river is known as Pranhita River. The climate of the sub-basin is characterized by hot summer from March to May with rainy season from June to September although the area has some rains in post monsoon season also. The upper catchment area lies in the high rainfall range of 2000-4000 mm. The Prahnita River joins the Godavari River on the left bank which drains the Eastern Coast in Andhra Pradesh and flows out to the Bay of Bengal.

3. Objective

1) To prepare land use and land cover maps of the Wainganga River Basin.
2) To classify major LULC categories such as agriculture, forest, water bodies, built-up land, wasteland, and others using supervised classification techniques.
3) To generate geospatial outputs that can support sustainable land use planning, watershed management, and policy decision-making in the Wainganga River Basin.

4. Methodology

Data forms the foundation of any scientific investigation, and the present study focuses on developing a comprehensive spatial and non-spatial database to support the preparation of an effective action plan for the Sina Basin.

Data Collection

Both primary and secondary data were utilized in this study. Secondary data constituted the major

input and were collected from reliable sources, obtained from one-inch topographic map of Survey of India (1:63360 or 1:250000). They are toposheet No. 55J, 55K, 55N, 55O, 55P, 56M, 64B, 64C, 64D, 65A. Includes sorting of data, digitization of various layers, preparation of maps, statistical analysis and with the help of GIS & RS technique land use and land cover classification through supervised classification method based on the field knowledge. Arc GIS 9.3 are powerful tool for extracting the land use and land cover layers from toposheet and satellite image.

5. Result and Discussion

Analysis through remote sensing techniques of the study area having a total area of 26,347.01 km^2 helped the authors identify and map a total of ten classes. These classes include Rocky land/ open space, dense Forest, water bodies, agriculture, sparse vegetation, fallow land, open Scrub, barren land, settlement, gravel land (Fig.2)

The Wainganga watershed composition and distribution of land use land cover classes of image include rocky land /open space, dense Forest, water bodies, agriculture, sparse vegetation, fallow land, open Scrub, barren land, settlement, gravel land. The major land use categories in the Wainganga River's basin includes build up land (1.89%) and agricultural land (14.17%) that comprises of generally kharif, rabi and double crop system in the region. Forest cover (65.75%) comprises of dense forest (15.03%), sparse vegetation (23.01%), open Scrub (27.71%) and recent plantations. Deciduous or dense forest largely spreads out in the region in the east of the all Wainganga river basin area. Forest cover comprises of deciduous forests, degraded forests, forest blanks and recent plantations. Water Bodies (2.11%), barren Land (9.48%), fallow Land (4.19%), gravel Land (0.52%), rocky Land or open Space (1.88%) can also be found in the region. Waste land with or without scrub and barren rocky/stony waste can also be found in the region.

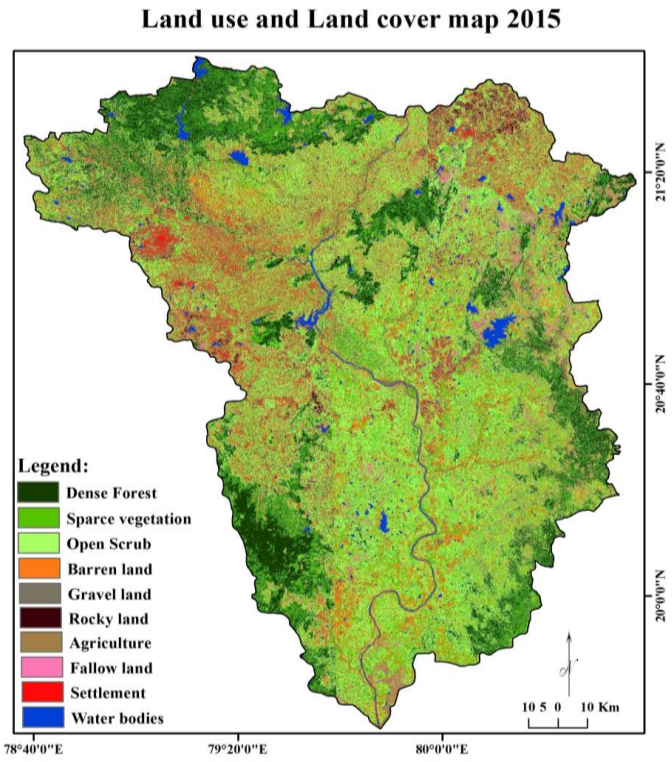

Figure 2 Land Use land cover map of Wainganga basin

5.1 Water bodies :

Water body includes the river's lakes and water reservoirs of the study area. Wainganga river is the main river of the study area.Some of the tributory are meet on the left side of the Wainganga river i.e.Bagh, Gadhavi, Satti, Topagrhi, Khobragarhi, Phuar, Pohar, pal and Kathani and also right side Pench, Kanhan, Ambi, Maru, Haman, Andhari, Mai, Patahri, Sur and Bawanthandi. In the year 2015, the total area under this category was 2.11%**.**

5.2 Forest

Forest class includes the natural deciduous and scanty vegetation cover in this area. Dense forest was 3960.89 km^2 which was 15.03% of the study area. Majorly in the north side of the found is dense forest. Sparse vegetation is observerd along the Wainganga river. The Wainganga river basin has 62.07% of its area under forests, including those owned by the States and communities. The major vegetation category observed in the Wainganga river basin area and the study area is scrub land. The major vegetation in the area is scrub and dense mixed forest. The main tree species observed in the area are Arjun, Ain, Bija, Mahua, Garadi, Ghoti, Mowai, Teak, Palas, Pipal, etc. drier localities, with lesser moisture content, Palas and Khair species are observed. According to Eco-sensitive zone notification of the MOEF, a substantial area of land around the periphery designated as a 'Buffer Zone' of the protected areas will now be considered as part of the Eco-sensitive zone. Although the notification does not recommended any change in land use, there would be certain restriction on development activities like industries, thermal power plants, mining etc. which may have detrimental impact on national park and eco-sensitive areas. Most of the Schedule tribe communities are currently engaged din subsistence agriculture, shifting cultivation or collection of minor forest produce like as Bamboo, Moha, Teak, Arjun, Hirada, Amla, Charoli, Behda, Nimb, Karanja, palas etc. as an economic activity.

Table 1: Wainganga Sub-basin LULC

Land use & Land cover			
Sr.No	**Land use / Land Cover Category**	**Area in sq.km.**	**Total Geographical Area (%)**
01	Rocky land/ Open space	495.49	1.88
02	Dense Forest	3960.89	15.03
03	Water bodies	558.21	2.11
04	Agriculture	3735.03	14.17
05	Sparse vegetation	6063.82	23.01
06	Fallow land	1101.28	4.19
07	Open Scrub	7299.50	27.71
08	Barren land	2497.43	9.48
09	Settlement	497.46	1.89
10	Gravel land	137.90	0.52
Total		**26347.01**	**100%**

(Source: Calculated by authors)

Fallow Land

The area under fallow was 1101.28 km^2 which was 4.19% of the study area. With the proprtionate increase in built up and sgriculture land (along with extensive irrigational practices) the area under this criteria is very less and found some city region.

Barren Land :

Barren class includes the bare exposed earth surface without vegetation. Barren land is seen in the areas of rugged topography.,the total area under this class are 2497.43 $km^{2.}$ In this area almost the entire part of central portion of the study area came under this category. Barren land paved the way of human habitation, dry farming and pasture.

Built up Land:

Built up land is an area of human habitation developed due to non-agriculture use and that has a cover of building, transport and communication, utilities in association with water, vegetation and vacant land(Suryawanshi,2011). Built up area is total area is 497.46 km^2. The settlements are mostly concentrated along the river and the agriculture area while they become sparse in the uplands and forested areas. Bhandara and Gondia are significantly dense in terms of human settlement. The main towns in the Gondia, Bhandara, Gadchiroli, Tumsar, Brahmapuri, Tiroda, Pauni, Umred, Ramtek etc. The major industrial zones in the Wainganga sub basin arein Mauda, Tiroda , tumsar and Pauni. The major industries include rice mills, dal mills, sugar industries and a thermal power station.

Agriculture Land:

The major part of the Wainganga River Basin is covered with agriculture land according to 14.17% of the total area and 2.11% of the basin is covered by water bodies. Population of the Wainganga river basin area mainly depends upon agricultural activity. The south west monsoon from June to October brings fruitful heavy rains to the river basin region. Kharip and rabbi are the main agricultural seasons in the region nonetheless, more cultivation is observed in kharip as compared to rabbi crop. Rice is generally drilled in the field by the end of June. Rice and tur is the largest cultivated crop in kharip season. The chief rabbi crops are wheat, jowar, linseed, gram and lac. Black gram, horse gram and green gram are the important pulses grown in the basin region.

Conclusion

The present study demonstrates that land use and land cover (LULC) inventories derived from remote sensing and GIS techniques are indispensable for understanding resource utilization patterns and for planning sustainable development in river basins. Using satellite imagery and GIS-based supervised classification, ten major LULC classes were identified and mapped for the Wainganga River Basin, covering a total geographical area of 26,347.01 km^2. The analysis reveals that forest cover dominates the basin, accounting for 65.75% of the total area, comprising dense forest, sparse vegetation, and open scrub. This highlights the ecological significance of the basin, particularly in terms of biodiversity conservation and environmental stability. Agricultural land occupies 14.17% of the basin area and remains the primary livelihood source for the local population, supported largely by monsoon rainfall and surface water resources. Built-up land, although currently limited to 1.89%, is concentrated along river courses and fertile agricultural zones, indicating localized urban and industrial growth.

Other land cover categories such as barren land (9.48%), fallow land (4.19%), water bodies (2.11%), rocky/open spaces (1.88%), and gravel land (0.52%) further reflect the geomorphological

diversity and varying land capability of the basin. The presence of extensive scrub and barren lands in the central and upland portions indicates areas of land degradation, which may require targeted soil and water conservation measures. The spatial distribution of settlements and infrastructure also suggests increasing pressure on riverine environments and agricultural lands. Overall, the findings emphasize the need for integrated basin-level planning that balances agricultural development, forest conservation, and controlled urban growth. The present study offers a scientific baseline for future LULC monitoring, impact assessment, and policy formulation, and will be useful for long-term planning and sustainable management of land and water resources in the Wainganga River Basin.

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