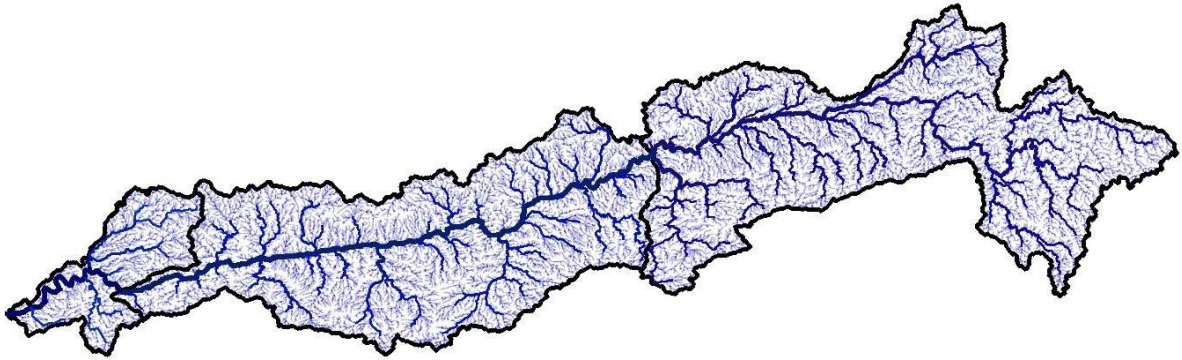




**National River Conservation Directorate**  
Ministry of Jal Shakti, Department of Water  
Resources,  
River Development & Ganga Rejuvenation  
Government of India

# Revenue Map of Narmada River Basin



**March 2025**



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# Revenue Map of Narmada River Basin



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### **National River Conservation Directorate (NRCD)**

The National River Conservation Directorate, functioning under the Department of Water Resources, River Development & Ganga Rejuvenation, and Ministry of Jal Shakti providing financial assistance to the State Government for conservation of rivers under the Centrally Sponsored Schemes of 'National River Conservation Plan (NRCP)'. National River Conservation Plan to the State Governments/ local bodies to set up infrastructure for pollution abatement of rivers in identified polluted river stretches based on proposals received from the State Governments/ local bodies.

[www.nrcd.nic.in](http://www.nrcd.nic.in)

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The Center for Narmada River Basin Management and Studies (cNarmada) is a Brain Trust dedicated to River Science and River Basin Management. Established in 2024 by IIT Gandhinagar and IIT Indore, under the supervision of cGanga at IIT Kanpur, the center serves as a knowledge wing of the National River Conservation Directorate (NRCD). cNarmada is committed to restoring and conserving the Narmada River and its resources through the collation of information and knowledge, research and development, planning, monitoring, education, advocacy, and stakeholder engagement.

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[www.cganga.org](http://www.cganga.org)

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This report is a comprehensive outcome of the project jointly executed by IIT Gandhinagar (Lead Institute) and IIT Indore (Fellow Institute) under the supervision of cGanga at IIT Kanpur. It was submitted to the National River Conservation Directorate (NRCD) in 2024. We gratefully acknowledge the individuals who provided information and photographs for this report.

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## PREFACE

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The Narmada River Basin, often referred to as the lifeline of central India, spans across four states—Madhya Pradesh, Gujarat, Maharashtra, and Chhattisgarh—encompassing a vast geographical area. It supports a million of people, sustaining agriculture, industry, and urban settlements while holding deep cultural and spiritual significance. Given its ecological and socio-economic importance, effective land and revenue mapping is essential for informed governance, sustainable development, and equitable resource management.

This report systematically categorizes land revenue classes across the Upper, Middle, and Lower Narmada Basins, analyzing key revenue-generating categories such as forests, agricultural land, water bodies, built-up areas, and barren land. The findings are derived from Sentinel satellite data (2024) and supplemented by state-level land-use statistics, providing a comprehensive assessment of the basin's land resources.

The report highlights the striking variations in land-use distribution across the basin. The Upper Narmada Basin, characterized by its dense forests (24.76% of its area) while the Middle Narmada Basin, with 63.75% agricultural land, serves as the agricultural heartland, supported by major reservoirs like Indira Sagar and Tawa. The Lower Narmada Basin, dominated by fertile plains and industrial zones, faces pressures from urban expansion, salinization, and land degradation, particularly in Bharuch and Vadodara.

One of the critical insights from this study is the Land-to-People Ratio (LtPR), which reveals disparities in resource availability. The report also identifies land degradation hotspots, with sheet erosion widespread in the Upper Basin, industrial and anthropogenic erosion in the Middle Basin, and salinization and gully erosion affecting the Lower Basin.

Despite the robust analysis, the study faces challenges, including the absence of basin-specific revenue records and inconsistencies in district-level data. Reliance on satellite imagery for land classification, while useful for mapping, does not provide direct revenue valuation. Additionally, the lack of granular village or block-level data limits precision in assessing localized land-use impacts. These gaps underscore the need for integrated geospatial databases and standardized data collection across states.

This report serves as a foundational document for policymakers, researchers, and stakeholders involved in river basin management, land-use planning, and sustainable development. It emphasizes the necessity of balanced approaches—conserving forests in

ecologically rich zones, promoting sustainable agriculture in fertile regions, and mitigating degradation in vulnerable areas. The recommendations provided aim to enhance governance, optimize resource use, and ensure long-term ecological stability in the Narmada Basin.

Centres for Narmada River Basin Management and Studies (cNarmada)

IIT Gandhinagar, IIT Indore

## TABLE OF CONTENTS

|                                                                             |            |
|-----------------------------------------------------------------------------|------------|
| <i>Preface</i>                                                              | <i>i</i>   |
| <i>Table of Contents</i>                                                    | <i>iii</i> |
| <i>List of Tables</i>                                                       | <i>vi</i>  |
| <i>List of Figures</i>                                                      | <i>vii</i> |
| <b>1. Introduction.....</b>                                                 | <b>1</b>   |
| <b>1.1. A brief overview of revenue mapping .....</b>                       | <b>2</b>   |
| <b>1.2. Area of Study.....</b>                                              | <b>3</b>   |
| <b>2. Land Revenue Categories.....</b>                                      | <b>4</b>   |
| <b>2.1. Sub-Basin Wise Land-Revenue Categories .....</b>                    | <b>7</b>   |
| 2.1.1 Area Under Water Bodies.....                                          | 7          |
| 2.1.2 Area Under Forest and Vegetation.....                                 | 8          |
| 2.1.3 Area Under Flooded Vegetation .....                                   | 9          |
| 2.1.4 Area Under Agricultural Land.....                                     | 9          |
| 2.1.5 Area Under Built-up Land.....                                         | 10         |
| 2.1.6 Area Under Bare ground .....                                          | 10         |
| <b>3. Upper Narmada Basin: Land Revenue Categories .....</b>                | <b>11</b>  |
| <b>3.1. Water Bodies .....</b>                                              | <b>11</b>  |
| <b>3.2. Dense Forest and Other Vegetation.....</b>                          | <b>12</b>  |
| <b>3.3. Flooded Vegetation .....</b>                                        | <b>14</b>  |
| <b>3.4. Agricultural Land .....</b>                                         | <b>14</b>  |
| <b>3.5. Area Under Different Agricultural Land Revenue Categories .....</b> | <b>14</b>  |
| <b>3.6. Built-up Land.....</b>                                              | <b>17</b>  |
| <b>3.7. Bare Ground.....</b>                                                | <b>17</b>  |
| <b>4. Middle Narmada Basin: Land Revenue Categories .....</b>               | <b>21</b>  |
| <b>4.1. Water Bodies .....</b>                                              | <b>21</b>  |
| <b>4.2. Dense Forests and Other Vegetation .....</b>                        | <b>22</b>  |
| <b>4.3. Flooded Vegetation .....</b>                                        | <b>23</b>  |
| <b>4.4. Agricultural Land .....</b>                                         | <b>23</b>  |
| <b>4.5. Area Under Different Agricultural Land Revenue Categories .....</b> | <b>24</b>  |
| <b>4.6. Built-up Land.....</b>                                              | <b>28</b>  |



|                                                                      |           |
|----------------------------------------------------------------------|-----------|
| 4.7. Bare Ground.....                                                | 29        |
| <b>5. Lower Narmada Basin: Land Revenue Categories .....</b>         | <b>29</b> |
| 5.1. Water Bodies .....                                              | 30        |
| 5.2. Dense Forests and Other Vegetation .....                        | 30        |
| 5.3. Flooded Vegetation .....                                        | 32        |
| 5.4. Agricultural Land .....                                         | 32        |
| 5.5. Area Under Different Agricultural Land Revenue Categories ..... | 33        |
| 5.6. Built-up Land.....                                              | 34        |
| 5.7. Bare Ground.....                                                | 38        |
| <b>6. Land-to-People Ratio (LtPR).....</b>                           | <b>38</b> |
| 6.1. Upper Narmada Basin LtPR .....                                  | 39        |
| 6.1.1 Forest LtPR .....                                              | 39        |
| 6.1.2 Non-Cultivable Land LtPR .....                                 | 40        |
| 6.1.3 Fallow Land LtPR .....                                         | 40        |
| 6.1.4 Net Sown Area LtPR.....                                        | 40        |
| 6.1.5 Area Sown More Than Once LtPR.....                             | 41        |
| 6.2. Middle Narmada Basin LtPR.....                                  | 41        |
| 6.2.1 Forest LtPR Patterns .....                                     | 41        |
| 6.2.2 Not Cultivable LtPR.....                                       | 41        |
| 6.2.3 Fallow Land LtPR .....                                         | 42        |
| 6.2.4 Net Sown Area LtPR.....                                        | 42        |
| 6.2.5 Area Sown More Than Once .....                                 | 43        |
| 6.3. Lower Narmada Basin LtPR .....                                  | 43        |
| 6.3.1 Forest LtPR .....                                              | 43        |
| 6.3.2 Not Cultivable LtPR.....                                       | 44        |
| 6.3.3 Fallow Land LtPR .....                                         | 44        |
| 6.3.4 Net Area Sown LtPR.....                                        | 44        |
| 6.3.5 Cropping Intensity.....                                        | 44        |
| <b>7. Vulnerable Areas.....</b>                                      | <b>44</b> |
| 7.1. Upper Narmada Basin.....                                        | 45        |
| 7.2. Middle Narmada Basin .....                                      | 47        |
| 7.3. Lower Narmada Basin .....                                       | 48        |

|                                                         |           |
|---------------------------------------------------------|-----------|
| <b>8. Challenges in Revenue Mapping.....</b>            | <b>49</b> |
| <b>9. Conclusion and Recommendations.....</b>           | <b>50</b> |
| <b>9.1. Summary and Key Findings .....</b>              | <b>51</b> |
| <b>9.2. Policy Recommendations and Suggestions.....</b> | <b>52</b> |

## LIST OF TABLES

|                                                                                                                    |    |
|--------------------------------------------------------------------------------------------------------------------|----|
| Table 1. Basin-wise Revenue Land Categories (in hectares) _____                                                    | 7  |
| Table 2. Basin-wise Revenue Land Categories (in percentage of the total area) _____                                | 8  |
| Table 3. District-wise Land Revenue Categories of Upper Narmada Basin (in hectares) _____                          | 13 |
| Table 4. Classification of Land in Each District of Upper Narmada Basin for The Year 2022-2023<br>(Hectare) _____  | 19 |
| Table 5. Classification of Land in Each District of Middle Narmada Basin for The Year 2022-2023<br>(Hectare) _____ | 26 |
| Table 6. District-wise Land Revenue Categories of Middle Narmada Basin (in hectares) _____                         | 28 |
| Table 7. District-wise Land Revenue Categories of Lower Narmada Basin (in hectares) _____                          | 31 |
| Table 8. Classification of Land in Each District of Lower Narmada Basin for The Year 2020-2021<br>(Hectare) _____  | 36 |
| Table 9. Land-to-People Ratio in Upper Narmada Basin Lower Basin, (ha per capita) _____                            | 39 |
| Table 10. Land-to-People Ratio in Middle Narmada Basin Lower Basin, (ha per capita) _____                          | 42 |
| Table 11. Land-to-People Ratio in Lower Narmada Basin Lower Basin, (ha per capita) _____                           | 43 |

## LIST OF FIGURES

|                                                                      |           |
|----------------------------------------------------------------------|-----------|
| <i>Figure 1. Study Area: Narmada River Basin</i>                     | <i>4</i>  |
| <i>Figure 2. Basin-wise Revenue Categories</i>                       | <i>6</i>  |
| <i>Figure 3. Upper Basin: District-wise Land-revenue Categories</i>  | <i>12</i> |
| <i>Figure 4. Upper Narmada Basin: Land Revenue Categories</i>        | <i>20</i> |
| <i>Figure 5. Middle Basin: District-wise Land-revenue Categories</i> | <i>22</i> |
| <i>Figure 6. Middle Narmada Basin: Land Revenue Categories</i>       | <i>27</i> |
| <i>Figure 7. Lower Basin: District-wise Land-revenue Categories</i>  | <i>32</i> |
| <i>Figure 8. Lower Narmada Basin: Land Revenue Categories</i>        | <i>37</i> |
| <i>Figure 9. Upper Basin: Land Degradation</i>                       | <i>46</i> |
| <i>Figure 10. Middle Narmada Basin: Land Degradation</i>             | <i>47</i> |
| <i>Figure 11. Lower Narmada Basin: Land Degradation</i>              | <i>48</i> |

## **1. Introduction**

The Revenue mapping of the Narmada River is a systematic approach aimed at identifying, categorizing, and documenting land resources to enhance governance, resource management, and better policy decisions. The Narmada River, which flows through the states of Madhya Pradesh, Gujarat, Maharashtra, and Chhattisgarh, plays a crucial role in supporting agricultural, industrial, and urban activities, often referred to as the lifeline of Central Indian states. The river basin is central to the socio-economic development of these regions.

The Narmada River basin's significance extends beyond its physical expanse; it serves as a vital source of water for irrigation, drinking, industrial processes, and hydropower generation. The basin is characterized by diverse ecosystems, ranging from fertile agricultural plains and dense forests to urban settlements and industrial zones. Spanning approximately 1,312 kilometers, it supports diverse ecosystems and sustains the livelihoods of millions of people who depend on its resources for agriculture, fishing, forestry, and various other economic activities. Moreover, the Narmada River holds deep cultural and spiritual importance for local communities.

Revenue mapping in the Narmada basin is very important for managing land and natural resources effectively. It involves keeping accurate land-use mapping, which helps to understand how the land is being used and ensures it is organized properly. This process allows land resources to be used in ways that boost economic growth while also protecting the environment. In areas where farming is common, revenue mapping helps improve crop production by planning better irrigation, managing soil health, and selecting suitable crops. It also helps create fair policies that support the sustainable use of resources.

The resources in the Narmada basin are facing more pressure due to increasing demands from agriculture, industrial growth, urbanization, and infrastructure development. Revenue

mapping plays a key role in tracking these resources, and ensuring they are used sustainably. It also helps identify areas that need conservation or restoration, making sure that economic progress goes hand in hand with protecting the environment.

The Narmada River basin also faces challenges like flooding and changes in water availability throughout the year. Revenue mapping helps assess risks linked to natural disasters, supports proper planning of flood-prone areas, and guides the creation of effective disaster management plans. By providing accurate information about land and water resources, it helps the region prepare for and respond to environmental challenges more effectively.

Additionally, revenue mapping is important for planning infrastructure development in the basin. Keeping detailed and updated land records makes it easier to plan and implement projects like irrigation systems, roads, industrial areas, and expanding cities. This organized approach ensures that development is carried out in a sustainable way, minimizing environmental damage and maximizing economic benefits.

### **1.1. A brief overview of revenue mapping**

Revenue mapping primarily involves creating detailed maps that classify land resources into distinct revenue categories. These categories include Forested Areas, Agricultural Land, er Water Bodies, Built-Up Land and Barren Land. Revenue mapping also considers people-to-land ratios to understand population pressure on land resources and to guide policies for equitable land use.

Remote sensing data has been successfully used to study how land use and land cover (LULC) have changed in the Narmada basin, providing useful information for better land management and revenue planning. By using GIS technology, satellite images help track LULC changes over time, making it easier to find revenue-generating areas such as agricultural lands, industrial zones, and urban settlements. This method helps make well-

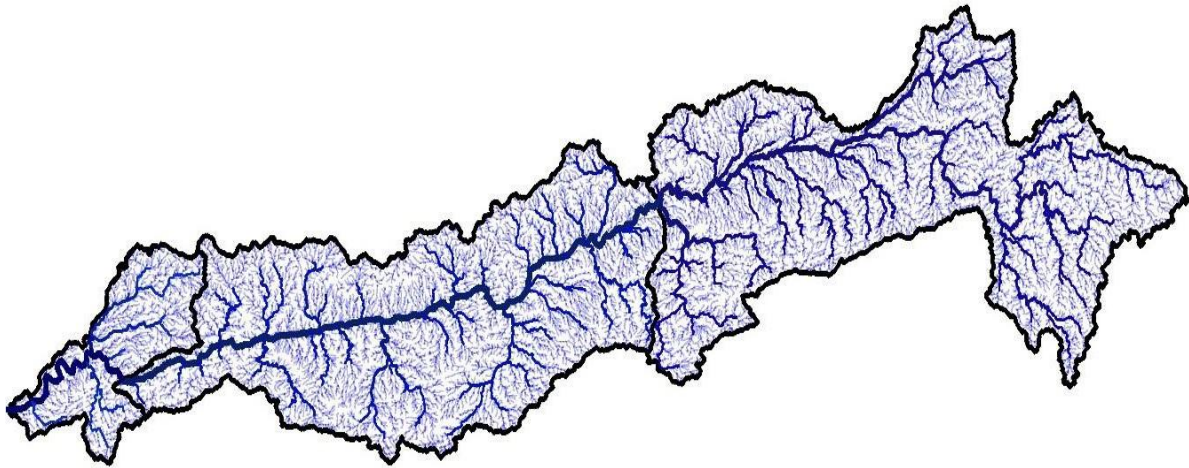
informed decisions to use resources more effectively, safeguarding revenue interests and promoting sustainable land management.

The revenue mapping of the Narmada River offers significant potential for improving governance, enhancing revenue generation, and promoting sustainable development. By providing accurate data, revenue mapping enables better decision-making and resource optimization throughout the Narmada River basin.

## **1.2. Area of Study**

The Narmada River basin is covering a large geographical area of approximately 97,162 square kilometres. This river basin spans across four Indian states: Chhattisgarh, Madhya Pradesh, Gujarat, and Maharashtra, covering significant portions of the central and western regions of the country. The Narmada River, which is sometimes called Madhya Pradesh's lifeline, originates from Amarkantak and travels 1,312 kilometres to the west before emptying into Gulf of Khambhat, Arabian Sea. In terms of state-wise length, Narmada River flows 1077 kms in Madhya Pradesh, 74 kms in Maharashtra, 161 kms in Gujarat. In addition to being large in area, its basin is essential to the region's ecology, society, and economy. The river benefits millions of people who live in its basin by providing essential water for drinking, agriculture, and hydropower.

The Narmada River Basin has a population of 20,799,195 and is spread across various states and districts. The Upper Narmada basin contains 8,603,425 people spread across 16 districts in Madhya Pradesh and 2 districts in Chhattisgarh, while the Middle Narmada Basin is made up of 9,126,886 people and covers 15 districts in Madhya Pradesh, 2 districts in Gujarat, and 2 districts in Maharashtra, and the Lower Basin has a population of 2,689,365 spread across 6 districts in Gujarat, 1 in Madhya Pradesh and 1 in Maharashtra.



***Figure 1. Study Area: Narmada River Basin***

Certain districts are only partially included within the Narmada River Basin. These districts exhibit significant diversity in terms of their economic conditions, demographic makeup, social structures, and geographical features. The population distribution across these areas is uneven, with some regions experiencing high population densities while others remain sparsely populated. Additionally, these areas are characterized by diverse cultural practices and social systems that influence local governance and community life. The terrain across the districts is varied, encompassing river valleys, fertile plains, and forested hills. This diverse landscape presents unique environmental challenges and opportunities within the Narmada River Basin.

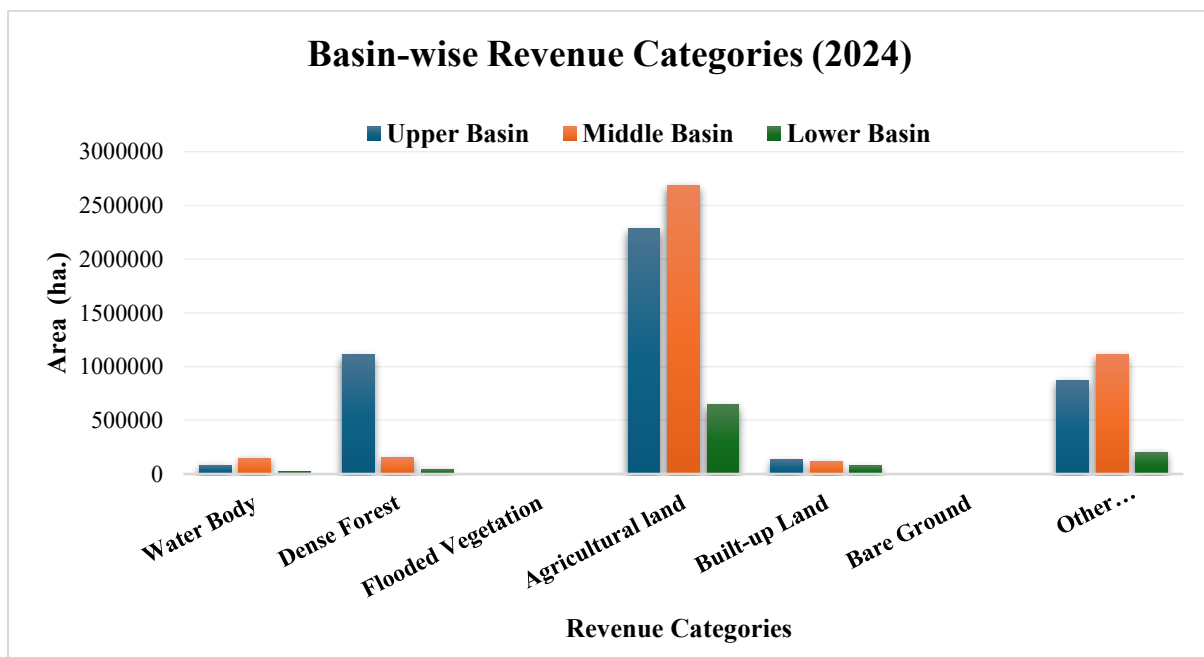
## **2. Land Revenue Categories**

The Narmada River Basin, one of the most significant river systems in India, encompasses a diverse range of land-use categories that directly influence its revenue generation and ecological balance. Understanding the land-revenue categories is crucial for effective resource management and sustainable development. This report focuses on the revenue categories of Forest, Agricultural Land, Non-cultivation Area, Water Bodies, Built-up Land and Barren Land. Forests play a vital role in maintaining the ecological health of the



Narmada River Basin. They act as carbon sinks, support biodiversity, and regulate the water cycle. The area under forests includes dense forests, open forests, and scrublands. These areas are often protected under government regulations, limiting their use for revenue generation but contributing indirectly through ecosystem services such as water purification, soil conservation, and climate regulation. Agricultural land is the backbone of the rural economy in the Narmada River Basin. It is further divided into the following subcategories: a) Fallow land refers to agricultural land that is temporarily uncultivated to restore its fertility. This practice is common in areas where crop rotation or soil conservation is necessary. Fallow land can be classified as current fallow (left uncultivated for one season) or long-term fallow (left uncultivated for more than a year). While fallow land does not generate immediate revenue, it is essential for maintaining long-term agricultural productivity. b) Sown area represents the portion of agricultural land that is actively cultivated and sown with crops during a given agricultural year. This category is a direct contributor to the basin's revenue, as it includes land used for growing food grains, cash crops, and other agricultural produce. The productivity of this land depends on factors such as soil quality, irrigation facilities, and farming practices. c) Irrigated land refers to agricultural areas that receive water from artificial sources such as canals, wells, or tube wells. This category is highly productive and contributes significantly to the basin's agricultural output. d) Area not available for cultivation includes land that is unsuitable for agricultural purposes due to physical or legal constraints. Examples include rocky terrain, and land occupied by infrastructure such as roads, railways, and industrial sites. While these areas do not contribute directly to agricultural revenue, they may generate income through other means, such as industrial activities or tourism. e) Water bodies in the Narmada River Basin include rivers, lakes, ponds, and reservoirs. These areas are essential for supporting aquatic ecosystems, providing water for irrigation, and sustaining livelihoods through fishing and tourism. While water bodies themselves do not generate land

revenue, their management and utilization can significantly impact the basin's overall economic output. f) Built-up land refers to areas occupied by human settlements, including residential, commercial, and industrial structures. Urbanization and infrastructure development have led to an increase in built-up land within the basin. This category contributes to revenue through property taxes, industrial output, and commercial activities. However, unchecked expansion of built-up land can lead to the loss of agricultural and forested areas, posing challenges for sustainable development. g) Barren land includes areas that are unproductive and unsuitable for cultivation or other uses. This category typically comprises rocky, sandy, or highly eroded land with little to no vegetation. While barren land does not contribute directly to revenue, it may have potential for rehabilitation or alternative uses such as solar energy projects or afforestation programs.



**Figure 2. Basin-wise Revenue Categories**  
Source: Calculated from Sentinel, 2024

## 2.1. Sub-Basin Wise Land-Revenue Categories

The Table 1 and Figure 2 provide a detailed breakdown of land-use categories across the Upper Basin, Middle Basin, and Lower Basin of the Narmada River Basin, with all values measured in hectares. The data highlights significant variations in land-use patterns, reflecting the diverse ecological and economic characteristics of each subbasin.

**Table 1. Basin-wise Revenue Land Categories (in hectares)**

| Basin Name     | Water Body | Dense Forest | Flooded Vegetation | Agricultural Land | Built-up Land | Bare Ground | Other Vegetation/ Shrubs/Trees |
|----------------|------------|--------------|--------------------|-------------------|---------------|-------------|--------------------------------|
| Upper Basin    | 83706.78   | 1110222.39   | 811.89             | 2282664           | 134360.24     | 1515.73     | 870735.29                      |
| Middle Basin   | 148504.59  | 152724.47    | 179.303            | 2688801.75        | 116258.37     | 319.42      | 1111275.43                     |
| Lower Basin    | 19769.5    | 43434.8      | 107.77             | 644837.83         | 78343.33      | 806.36      | 202664.96                      |
| Category Total | 251980.87  | 1306381.66   | 1098.963           | 5616303.58        | 328961.94     | 2641.51     | 2184675.68                     |

*Source: Calculated from Sentinel, 2024*

### 2.1.1 Area Under Water Bodies

Starting with water body, the Middle Basin dominates with 148,504.59 hectares of the total area), due to the presence of major reservoirs, dams, and extensive stretches of the Narmada River. The Upper Basin follows with 83,706.78 hectares (1.86% of the total area), which can be attributed to smaller tributaries and natural water bodies, while the Lower Basin has the least area under water bodies at 19,769.5 hectares due to its proximity to the river's delta where water spreads out and becomes less concentrated. However, in terms of percentage of water body to the total area, In terms of dense forest, the Upper Basin dominates both in absolute and relative terms, with 1,110,222.39 hectares (24.760%). This high percentage reflects the ecological richness of the upper reaches, where natural vegetation is preserved due to lower human interference and higher rainfall. The Lower Basin has a moderate dense forest cover of 43,434.8 hectares (4.388%), while the Middle Basin has the least

at 152,724.47 hectares (3.621%), likely due to higher agricultural and urban development. This indicates that the Upper Basin plays a critical role in biodiversity conservation, whereas the Lower and Middle Basins may face challenges related to soil erosion and reduced ecological resilience (see Table 1, Table 2 and Figure 2).

Table 2 shows that Lower Narmada Basin (1.99%) is second after Middle Narmada Basin (3.52%). This distribution suggests that the Middle Basin has better water availability for irrigation, hydropower, and ecosystem services compared to the other subbasins.

### 2.1.2 Area Under Forest and Vegetation

In terms of dense forest, the Upper Basin dominates both in absolute and relative terms, with 1,110,222.39 hectares (24.760%). This high percentage reflects the ecological richness of the upper reaches, where natural vegetation is preserved due to lower human interference and higher rainfall. The Lower Basin has a moderate dense forest cover of 43,434.8 hectares (4.388%), while the Middle Basin has the least at 152,724.47 hectares (3.621%), likely due to higher agricultural and urban development. This indicates that the Upper Basin plays a critical role in biodiversity conservation, whereas the Lower and Middle Basins may face challenges related to soil erosion and reduced ecological resilience (see Table 1, Table 2 and Figure 2).

**Table 2. Basin-wise Revenue Land Categories (in percentage of the total area)**

| Basin Name            | Water Body   | Dense Forest  | Flooded Vegetation | Agricultural land | Built-up Land | Bare Ground  | Other Vegetation/ Shrubs/Trees |
|-----------------------|--------------|---------------|--------------------|-------------------|---------------|--------------|--------------------------------|
| Upper Basin           | 1.867        | 24.760        | 0.018              | 50.907            | 2.996         | 0.034        | 19.419                         |
| Middle Basin          | 3.521        | 3.621         | 0.004              | 63.745            | 2.756         | 0.008        | 26.346                         |
| Lower Basin           | 1.997        | 4.388         | 0.011              | 65.137            | 7.914         | 0.081        | 20.472                         |
| <b>Category Total</b> | <b>2.600</b> | <b>13.479</b> | <b>0.011</b>       | <b>57.948</b>     | <b>3.394</b>  | <b>0.027</b> | <b>22.541</b>                  |

*Source: Authors' Calculation based on Sentinel 2024 data*

Area under other vegetation, shrubs, and trees is highest in the Middle Basin at 1,111,275.43 hectares (26.346%), which includes scrublands, grasslands, and scattered trees. The Lower Basin follows with 202,664.96 hectares (20.472%), while the Upper Basin has 870,735.29 hectares (19.419%). This indicates that the Middle Basin benefits from diverse vegetation, supporting biodiversity and ecosystem services, whereas the Upper and Lower Basins, while having significant vegetation cover, may need to focus on afforestation and land restoration in certain areas.

### **2.1.3 Area Under Flooded Vegetation**

The category of flooded vegetation is minimal across all subbasins, with the Upper Basin having the highest area at 811.89 hectares, likely due to seasonal flooding that supports wetland ecosystems in the Bargi Dam Reservoir (spread over Seoni, Mandla and Jabalpur districts), Tawa Reservoir (spread over Hoshangabad district) and Barana Reservoir (spread over Raisen district). The Lower Basin follows with 107.77 hectares (0.011%), and the Middle Basin has the least at 179.30 hectares (0.004%). It is noted that Indira Sagar Reservoir situated in the middle basin which has flooded vegetation and on the other hand Lower Basin has compatibility more flooded vegetation than the Middle Basin as a significant portion of the lower basin comes in contact with the Arabian sea (see Figure 8) however Narmada River forms an estuary rather than the other deltas.

### **2.1.4 Area Under Agricultural Land**

Agricultural land is most extensive in the Middle Basin, covering 2,688,801.75 hectares (63.745%), driven by fertile soils, favorable climatic conditions, and extensive irrigation facilities (Table 1 and Table 2). The Lower Basin follows closely with 644,837.83 hectares (65.137%), likely due to fertile soils near the river's delta and irrigation facilities. The Upper Basin has 2,282,664 hectares (50.907%), which is still significant but lower due to its hilly terrain (Table 2). This makes the Middle and Lower Basins the agricultural hubs of the

Narmada River Basin, contributing significantly to food production and rural livelihoods, whereas the Upper Basin, while still agriculturally active, has a lower proportion of agricultural land due to its topography.

### **2.1.5 Area Under Built-up Land**

When it comes to built-up land, the Lower Basin has the highest area at 78,343.33 hectares (7.914%), likely due to urbanization and industrial development near the river's delta. The Upper Basin follows with 134,360.24 hectares (2.996%), reflecting the presence of towns such as Jabalpur and small cities, while the Middle Basin has the least built-up area at 116,258.37 hectares (2.756%), indicating lower share of urban expansion (Table 2). This suggests that the Lower Basin's higher percentage of built-up land may lead to challenges related to land-use conflicts and environmental degradation, while the Middle Basin, with less urbanization, may have better-preserved natural landscapes.

### **2.1.6 Area Under Bare ground**

The category of bare ground is minimal across all subbasins. The Lower Basin has the highest area at 806.36 hectares (0.081%), due to rocky or eroded terrain in the eastern part of the Lower Basin. The Middle Basin has the least bare ground at 319.42 hectares (0.008%), indicating better land cover and soil conservation practices, while the Upper Basin has 1,515.73 hectares (0.034%), reflecting some areas of rocky or eroded terrain (Table 2). This highlights potential challenges related to soil erosion and land degradation in the Lower Basin, whereas the Middle Basin appears to have more effective land management practices

Thus, the above analysis and data shows that Narmada River Basin presents significant variation in land-use patterns across its subbasins. The Middle Basin stands out as the most agriculturally productive and ecologically diverse, with extensive agricultural land

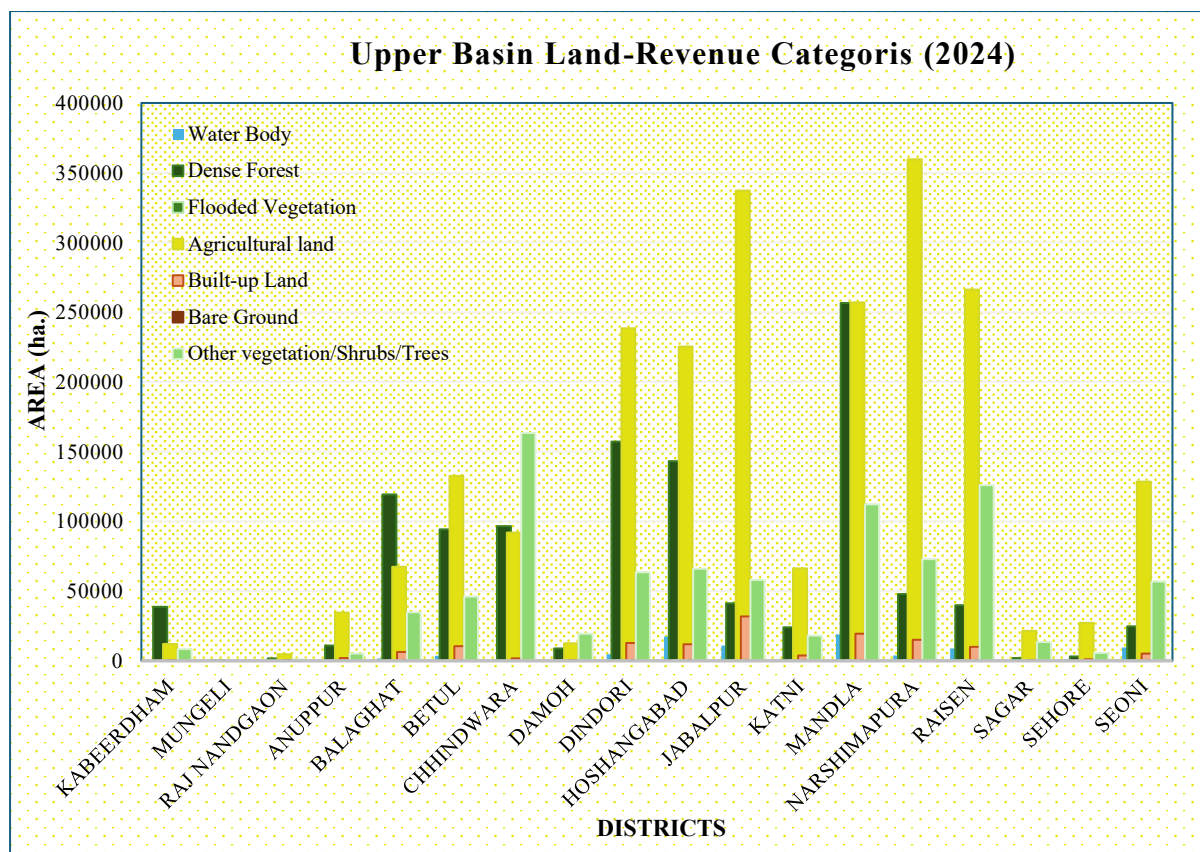
(2,688,801.75 hectares; 63.745%) and other vegetation (1,111,275.43 hectares; 26.346%). The Upper Basin is rich in dense forests (1,110,222.39 hectares; 24.760%) and water resources (83,706.78 hectares; 1.867%) but faces challenges related to urbanization (134,360.24 hectares; 2.996%) and bare ground (1,515.73 hectares; 0.034%). The Lower Basin, with the highest proportion of agricultural land (644,837.83 hectares; 65.137%) and built-up land (78,343.33 hectares; 7.914%), may require focused efforts on sustainable development and ecological restoration. Understanding these patterns is crucial for balanced development and conservation in the region, ensuring the long-term prosperity of the Narmada River Basin.

### **3. Upper Narmada Basin: Land Revenue Categories**

Like whole Narmada Basin, Upper Narmada Basin is rich in forest and agricultural land categories, and it also contains some big cities like Jabalpur. The Table 3 provides a detailed breakdown of land-use categories across various districts within the Narmada River Basin focusing on the key land-use categories: water bodies, dense forests, flooded vegetation, agricultural land, built-up land, bare ground, and other vegetation/shrubs/trees.

#### **3.1. Water Bodies**

Water bodies are most extensive in Mandla, covering 18,954.53 hectares, followed by Hoshangabad (17,285.81 ha) and Dindori (4,712.26 ha) as there are two major water bodies i.e. Bargi Dam reservoir and Tawa reservoir present in these district. In contrast, some other districts such as Kabeerdham (369.73 ha) and Raj Nandgaon (23.64 ha) have relatively smaller water bodies. On the lower end, districts like Mungeli do not report any significant water body coverage, indicating a landscape that is either dry or where water bodies are too small to be classified. It is noted that Mungeli district does not have any major water body as its very small part comes under the Upper Narmada Basin.



**Figure 3. Upper Basin: District-wise Land-revenue Categories**

Source: Calculated from Sentinel, 2024

### 3.2. Dense Forest and Other Vegetation

Mandla stands out as the most densely forested district, with 256,641.82 hectares under forest cover. Dindori (157,084.91 ha) and Hoshangabad (143,113.64 ha) also have substantial forested areas, reflecting their ecological richness and possibly their protection under conservation policies. Other districts with significant forest cover include Betul (94,283.27 ha) and Chhindwara (96,517.75 ha), which are known for their hilly terrain and greenery. On the other hand, districts such as Sagar (1,951.93 ha) and Mungeli (17.74 ha) have the lowest dense forest cover, indicating either extensive agricultural use or urban expansion reducing forested areas.



**Table 3. District-wise Land Revenue Categories of Upper Narmada Basin (in hectares)**

| District     | Water Body | Dense Forest | Flooded Vegetation | Agricultural land | Built-up Land | Bare Ground | Other Vegetation/ Shrubs/ Trees |
|--------------|------------|--------------|--------------------|-------------------|---------------|-------------|---------------------------------|
| Kabeerdham   | 369.73     | 38783.92     | 0.02               | 12011.03          | 705.25        | NA          | 8404.78                         |
| Mungeli      | NA         | 17.74        | NA                 | NA                | NA            | NA          | 9.44                            |
| Raj Nandgaon | 23.64      | 1692.13      | NA                 | 4645.99           | 692.68        | 0.29        | 958.94                          |
| Anuppur      | 539.69     | 11015.45     | 0.33               | 34464.80          | 2046.59       | 0.47        | 5272.86                         |
| Balaghat     | 1655.48    | 119215.88    | 8.18               | 67323.55          | 6441.41       | 38.54       | 34751.85                        |
| Betul*       | 3576.32    | 94283.27     | 231.34             | 132608.51         | 10566.07      | 59.34       | 46089.95                        |
| Chhindwara   | 828.57     | 96517.75     | NA                 | 91881.51          | 1663.21       | 1.74        | 163401.42                       |
| Damoh        | 337.79     | 8917.30      | 0.08               | 12521.03          | 554.37        | NA          | 19501.78                        |
| Dindori      | 4712.26    | 157084.91    | 0.79               | 238336.69         | 12809.15      | 4.37        | 63484.49                        |
| Hoshangabad* | 17285.81   | 143113.64    | 284.00             | 225431.57         | 11965.92      | 697.92      | 66019.92                        |
| Jabalpur     | 10999.84   | 41279.86     | 111.85             | 337114.44         | 31862.34      | 27.88       | 57948.80                        |
| Katni        | 1090.75    | 24053.55     | 0.33               | 66288.96          | 3797.71       | 20.14       | 18121.19                        |
| Mandla       | 18954.53   | 256641.82    | 162.73             | 256951.65         | 19526.59      | 177.44      | 112105.72                       |
| Narshimpura  | 3910.57    | 48001.25     | 2.05               | 359613.83         | 15015.35      | 231.84      | 72936.53                        |
| Raisen*      | 8932.11    | 39884.98     | 7.82               | 266307.38         | 10026.39      | 176.04      | 125929.51                       |
| Sagar        | 72.07      | 1951.93      | NA                 | 21437.76          | 576.35        | NA          | 13468.92                        |
| Sehore*      | 951.87     | 3061.48      | NA                 | 27214.08          | 992.83        | 59.96       | 5564.91                         |
| Seoni        | 9465.75    | 24705.53     | 2.37               | 128511.22         | 5118.03       | 19.76       | 56764.28                        |

*Source: Authors' Calculation based on Sentinel Data, 2024*

*\*Districts are part of both the Upper and Middle Narmada Basins and their area is shown in the respective basins. This table shows statistics for Upper Basin only.*

*NA shows that very small part of a district comes under Middle Narmada Basin and that particular area does not have significant water bodies*

Other vegetation, including shrubs and mixed tree cover, varies significantly across districts.

Chhindwara has the highest coverage in this category, with 163,401.42 hectares, followed by Mandla (112,105.72 ha) and Raisen (125,929.51 ha). These districts may have a mix of forest patches, plantation areas, or natural vegetation interspersed with other land uses. Additional districts with notable vegetation coverage include Betul (46,089.95 ha) and Dindori (63,484.49 ha). On the lower end, districts such as Mungeli (9.44 ha) and Kabeerdham

(8,404.78 ha) report minimal vegetation cover, indicating a more fragmented landscape with limited natural green spaces.

### **3.3. Flooded Vegetation**

Flooded vegetation, which includes marshy or seasonally inundated areas, is relatively rare across the districts. Hoshangabad records the highest flooded vegetation at 284.00 hectares, followed by Betul (231.34 ha) and Mandla (162.73 ha). Other districts report negligible flooded vegetation, with many (Mungeli, Raj Nandgaon, Sehore, Sagar and Chhindwada) recording no data at all, suggesting that wetland ecosystems are not widespread as there no large water bodies are present in these districts. However, the reason for the absence of flooded vegetation in the Raj Nandgaon district is that it has only a small portion within the Upper Narmada Basin, and that specific area does not contain any flooded vegetation.

### **3.4. Agricultural Land**

Agricultural landforms a major component of land use across the districts. Narshimpura has the highest agricultural land area, covering 359,613.83 hectares, followed closely by Jabalpur (337,114.44 ha) and Mandla (256,951.65 ha). This suggests that these districts have favorable conditions for farming, either through fertile soil, irrigation availability, or long-standing agrarian traditions. Other districts with significant agricultural land include Hoshangabad (225,431.57 ha) and Dindori (238,336.69 ha). In contrast, districts like Mungeli and Damoh have relatively smaller agricultural land coverage, likely due to limitations in soil fertility, water availability, or land suitability for farming.

### **3.5. Area Under Different Agricultural Land Revenue Categories**

The Upper Narmada Basin presents remarkable diversity in different land-revenue categories across its districts, reflecting varying ecological conditions, agricultural practices, and development pressures. A detailed examination of the land classification data reveals several critical trends and inter-district variations that are crucial for sustainable basin management

(Table 4). However, the data in this section is not limited to the basin boundaries but covers the entire district over which Narmada Basin is spread. Therefore, this data provides insights into the districts within the basin rather than the specific areas of each district that are part of the basin.

Non-agricultural land includes settlements, industries, roads, and other infrastructure, reflecting the level of urbanization in each district. Sagar district tops this category with 70,416 hectares (including 12,306 ha of barren land), followed by Damoh (92,396 ha) and Balaghat (56,885 ha). These substantial figures reflect the challenging terrain and soil conditions in these areas. Katni (68,819 ha) and Raisen (44,629 ha) show moderate values, while Narsinghpur demonstrates the most efficient land utilization with just 21,926 hectares classified as uncultivable, followed by Hoshangabad (46,447 ha) and Mandla (55,857 ha). The significant variation in this category - ranging from Sagar's high values to Narsinghpur's low figure - underscores the basin's geological diversity and varying degrees of land degradation (Table 4).

Other Uncultivated Land, comprising permanent pastures, grazing lands, and cultivable wasteland, shows Chhindwara leading with 84,055 hectares (including 24,725 ha of culturable wasteland), followed by Betul (66,156 ha) and Sagar (81,706 ha). These substantial areas represent both challenges and opportunities for land reclamation and improved productivity. Balaghat (34,799 ha), Raisen (36,323 ha), and Seoni (43,644 ha) show moderate values, while Kabirdham (32,802 ha), Rajnandgaon (26,895 ha), and Umari (31,585 ha) report the lowest figures in this category. The presence of significant uncultivated land in several districts suggests potential for agricultural expansion through proper land development initiatives.

Fallow Land patterns reveal Anuppur maintaining the highest area at 48,235 hectares, followed closely by Dindori (44,872 ha) and Chhindwara (46,440 ha). These substantial fallow areas indicate the persistence of traditional crop rotation systems and possibly land fertility management practices. Mandla (38,061 ha), Balaghat (15,799 ha), and Betul (18,524 ha) show moderate fallow land, while Narsinghpur (6,090 ha), Damoh (5,757 ha), and Raisen (4,808 ha) demonstrate the most intensive cultivation practices with minimal land left fallow. These differences likely reflect varying agricultural traditions, irrigation access, and soil management approaches across the basin.

Net Sown Area highlights Sagar as the agricultural powerhouse with 557,028 hectares under cultivation, followed by Raisen (429,314 ha) and Narsinghpur (317,790 ha). These districts form the core of the basin's agricultural productivity, benefiting from relatively flatter terrain and better irrigation access. Chhindwara (506,137 ha) and Betul (466,281 ha) show strong agricultural presence despite their significant forest cover, while at the other end, Umaria (123,472 ha), Dindori (220,211 ha), and Kabirdham (186,673 ha) have limited cultivated areas due to their more rugged topography and extensive forests. The variations in net sown area clearly reflect the basin's transition from forested highlands to agricultural plains.

Cropping Intensity (area sown more than once) reveals even more striking patterns, with Hoshangabad showing remarkable performance at 598,881 hectares of cropped area (184% intensity), followed by Sagar (543,358 ha) and Narsinghpur (304,336 ha). These high-intensity districts demonstrate successful irrigation adoption and advanced agricultural practices. Seoni (346,959 ha), Raisen (371,524 ha), and Betul (369,724 ha) show strong moderate performance, while Rajnandgaon (73,388 ha), Kabirdham (110,277 ha), and Umaria (90,834 ha) lag significantly in cropping intensity, indicating substantial potential for agricultural improvement through better water management and farming techniques.

The Upper Narmada Basin presents a complex and diverse land use pattern, with a mix of forests, agriculture, and barren lands. While districts such as Mandla, Balaghat, and Chhindwara retain extensive forest cover, others like Sagar and Hoshangabad have transformed into intensive agricultural zones. The high presence of culturable waste land in certain districts highlights the potential for future agricultural expansion, afforestation, and land reclamation projects. Thus, land use patterns in the Upper Narmada Basin reflect a balance between conservation, agriculture, and development, making it a region of significant environmental and economic importance. Sustainable land management practices, combined with improved irrigation and afforestation efforts, can further enhance the productivity and ecological stability of the region.

### **3.6. Built-up Land**

Urbanization and infrastructure development are reflected in the built-up land category. Jabalpur, a major urban center, has the highest built-up land, covering 31,862.34 hectares, followed by Mandla (19,526.59 ha) and Narshimpura (15,015.35 ha). These figures indicate higher population density, industrialization, or expanding urban settlements. Other districts with moderate built-up land include Hoshangabad (11,965.92 ha) and Betul (10,566.07 ha). In contrast, some districts like Mungeli and Damoh report minimal built-up land, suggesting a predominantly rural character with limited urban development.

### **3.7. Bare Ground**

Bare ground, which includes exposed soil, rocky terrain, or areas with minimal vegetation, is not widespread in most districts. The highest bare ground coverage is observed in Hoshangabad (697.92 ha) and Narshimpura (231.84 ha), suggesting some areas with degraded land or rocky surfaces. Many districts, including Kabeerghat and Sagar, report no significant bare ground, which may indicate better soil cover or effective land management practices.

The land cover distribution highlights significant regional variations. Mandla and Dindori emerge as forest-rich districts, while Narshimapura and Jabalpur stand out for their extensive agricultural land. Built-up land is most prominent in Jabalpur, indicating higher urbanization levels. Meanwhile, districts like Mungeli, with minimal coverage across most categories, reflect a landscape with less environmental diversity. These variations likely stem from differences in topography, climate, water availability, and human land use practices across the districts.

**Table 4. Classification of Land in Each District of Upper Narmada Basin for The Year 2022-2023 (Hectare)**

| District       | Classification of reporting Area |                                  |                              |                |                                               |                                             |                       |                |                                         |                |                  | Net Area Sown | Cropped Area | Area Sown More Than Once (14 - 13) |
|----------------|----------------------------------|----------------------------------|------------------------------|----------------|-----------------------------------------------|---------------------------------------------|-----------------------|----------------|-----------------------------------------|----------------|------------------|---------------|--------------|------------------------------------|
|                | Forests                          | Not available for Cultivation    |                              |                | Other Uncultivated Land Excluding Fallow Land |                                             |                       |                | Fallow Land                             |                |                  |               |              |                                    |
|                |                                  | Area under Non Agricultural Uses | Barren and Unculturable Land | Total (3 To 4) | Permanent Pasture and other Grazing Land      | Misc. Tree Crops and Groves not included in | Culturable waste Land | Total (6 To 8) | Fallow Lands other than current fallows | Current Fallow | Total (10 To 11) |               |              |                                    |
| 1              | 2                                | 3                                | 4                            | 5              | 6                                             | 7                                           | 8                     | 9              | 10                                      | 11             | 12               | 13            | 14           | 15                                 |
| Madhya Pradesh |                                  |                                  |                              |                |                                               |                                             |                       |                |                                         |                |                  |               |              |                                    |
| Anuppur        | 76448                            | 33195                            | 24697                        | 57892          | 15180                                         | 480                                         | 15166                 | 30826          | 22000                                   | 26235          | 48235            | 161270        | 223868       | 62598                              |
| Balaghat       | 505078                           | 47654                            | 9231                         | 56885          | 30514                                         | 711                                         | 3574                  | 34799          | 7780                                    | 8019           | 15799            | 311939        | 456130       | 144191                             |
| Betul          | 395047                           | 32013                            | 29779                        | 61792          | 28033                                         | 553                                         | 37570                 | 66156          | 15130                                   | 3394           | 18524            | 466281        | 836005       | 369724                             |
| Chhindwara     | 477385                           | 50658                            | 20248                        | 70906          | 59234                                         | 96                                          | 24725                 | 84055          | 24674                                   | 21766          | 46440            | 506137        | 933443       | 427306                             |
| Damoh          | 267118                           | 33275                            | 59121                        | 92396          | 35012                                         | 46                                          | 5209                  | 40267          | 2255                                    | 3502           | 5757             | 323045        | 630522       | 307477                             |
| Dindori        | 25343                            | 28955                            | 10972                        | 39927          | 13525                                         | 16                                          | 15041                 | 28582          | 18933                                   | 25939          | 44872            | 220211        | 337442       | 117231                             |
| Hoshangabad    | 256130                           | 44077                            | 2370                         | 46447          | 25289                                         | 16                                          | 8677                  | 33982          | 3131                                    | 3090           | 6221             | 325909        | 924790       | 598881                             |
| Jabalpur       | 77642                            | 43651                            | 36963                        | 80614          | 38193                                         | 142                                         | 27194                 | 65529          | 11471                                   | 11313          | 22784            | 273188        | 622387       | 349199                             |
| Katni          | 100028                           | 35074                            | 33745                        | 68819          | 38672                                         | 104                                         | 26316                 | 65092          | 10199                                   | 12161          | 22360            | 236793        | 435730       | 198937                             |
| Mandla         | 593221                           | 45084                            | 10773                        | 55857          | 20601                                         | 64                                          | 24975                 | 45640          | 18547                                   | 19514          | 38061            | 232780        | 395267       | 162487                             |
| Narsinghpur    | 136184                           | 20906                            | 1020                         | 21926          | 24198                                         | 166                                         | 7297                  | 31661          | 3645                                    | 2445           | 6090             | 317790        | 622126       | 304336                             |
| Raisen         | 333672                           | 41069                            | 3560                         | 44629          | 26366                                         | 109                                         | 9848                  | 36323          | 2287                                    | 2521           | 4808             | 429314        | 800838       | 371524                             |
| Sagar          | 297932                           | 58110                            | 12306                        | 70416          | 72293                                         | 561                                         | 8852                  | 81706          | 9758                                    | 5919           | 15677            | 557028        | 1100386      | 543358                             |
| Seoni          | 328545                           | 50170                            | 11828                        | 61998          | 20559                                         | 31                                          | 23054                 | 43644          | 11873                                   | 15948          | 27821            | 413393        | 760352       | 346959                             |
| Umaria         | 236714                           | 29743                            | 8805                         | 38548          | 15020                                         | 220                                         | 16345                 | 31585          | 11416                                   | 8594           | 20010            | 123472        | 214306       | 90834                              |
| Chhattisgarh   |                                  |                                  |                              |                |                                               |                                             |                       |                |                                         |                |                  |               |              |                                    |
| Kabirdham      | 189451                           | 16637                            | 9966                         | 26603          | 29006                                         | 67                                          | 3729                  | 32802          | 4743                                    | 4433           | 9176             | 186673        | 296950       | 110277                             |
| Rajnandgaon    | 81950                            | 28187                            | 4095                         | 32282          | 18535                                         | 186                                         | 8174                  | 26895          | 7225                                    | 7378           | 14603            | 182426        | 255814       | 73388                              |

Source: Directorate of Economics & Statistics (2022-2023), Land Use Statistics of respective states



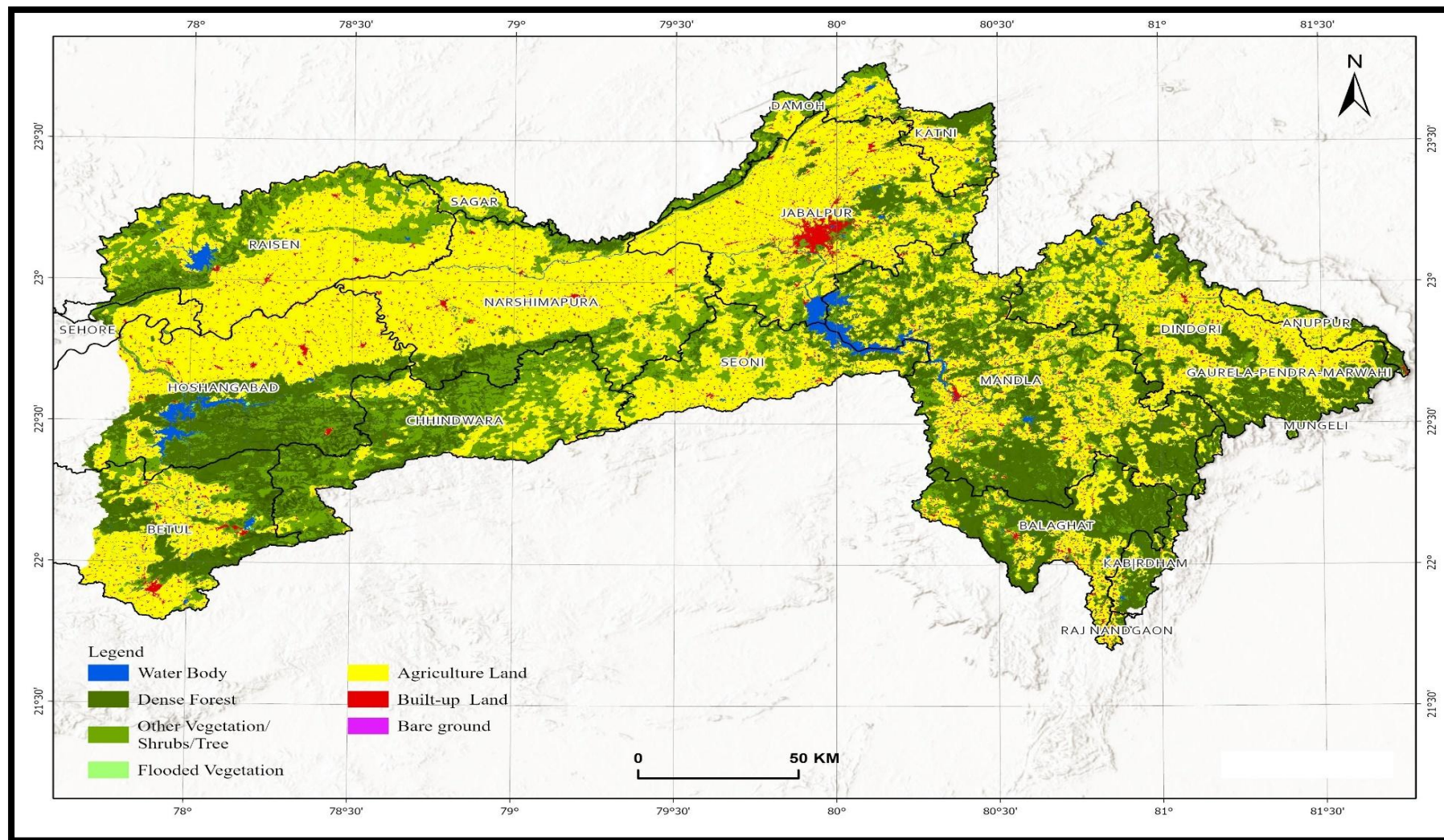


Figure 4. Upper Narmada Basin: Land Revenue Categories  
Source: Calculated from Sentinel, 2024



#### **4. Middle Narmada Basin: Land Revenue Categories**

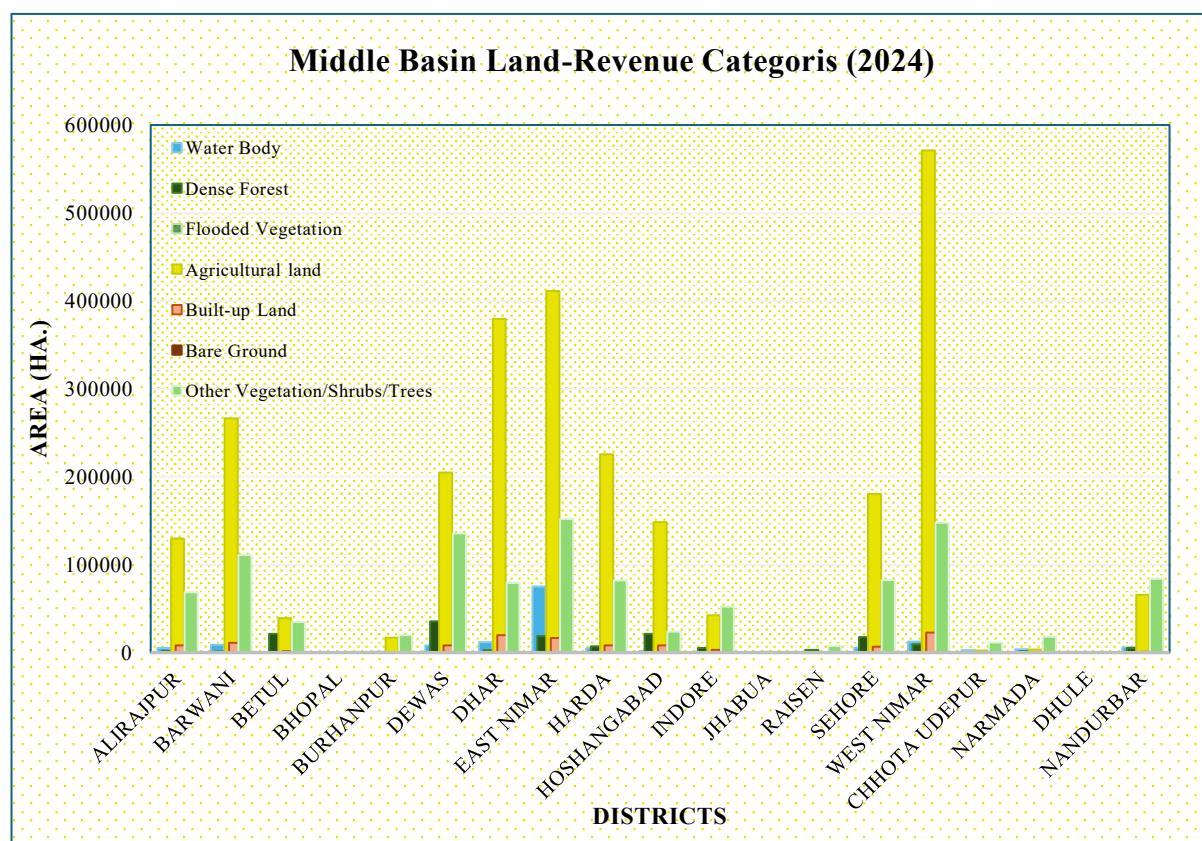
Middle Narmada Basin contribute significantly to the agricultural, and forest-vegetation categories its nearly 63% land goes to agriculture and related activities followed by 10% percent (Table 2) to both forest and vegetation categories. Table 6 presents a detailed district wise breakup of land-revenue categories for assessing the current status of different land-revenue categories in each district (see also Figure 5). These categories have been discussed in detail with the respect of districts.

##### **4.1. Water Bodies**

The water resources across the Middle Narmada Basin shows district wise remarkable variation. East Nimar (Khandwa) district stands out with 75,081 hectares of water bodies, primarily due to the massive Indira Sagar reservoir. Dhar (12,011 ha) and West Nimar (Khargone) (12,654 ha) follow closely, benefiting from the Narmada's major tributaries and irrigation projects. It is also important to note that East Nimar is one of the largest districts iunder the total Middle Basin Area and west Nimar contains reservoirs like Dejla Dewada Dam and Ambak Nalla reservoir. Alirajpur (5,289 ha), Nandurbar (6,036 ha), and Dewas (8,028 ha) have moderate water resources from smaller rivers, tanks, and check dams. Barwani (8,925 ha) and Harda (4,914 ha) maintain stable water availability through seasonal streams and ponds. At the lower end, urban centers like Indore (691 ha) and Bhopal (0 ha) show minimal natural water bodies. This is not because Bhopal district lacks water bodies, but rather because only a small part of Bhopal district falls within the Middle Narmada Basin, and that specific area does not contain any significant water bodies. The extreme cases of Jhabua (5.5 ha) highlight severe water scarcity in these drought-prone regions, while Burhanpur (742 ha) and Chhota Udepur (2,559 ha) have comparatively better water bodies area in the west of Middle Narmada Basin (Table 6).

## 4.2. Dense Forests and Other Vegetation

Forest cover distribution reveals the ecological diversity of the region. Dewas leads with 35,409 hectares of dense forests in the Satpura foothills, followed by Betul (21,358 ha) and Hoshangabad (21,406 ha) which form crucial wildlife corridors connecting Satpura and Vindhya ranges. Sehore (17,750 ha), East Nimar (18,813 ha), and Harda (6,975 ha) show



**Figure 5. Middle Basin: District-wise Land-revenue Categories**

moderate but vital forest patches (Table 6). Alirajpur (1,934 ha), Barwani (1,304 ha), and

*Source: Calculated from Sentinel, 2024*

Nandurbar (5,425 ha) demonstrate how tribal areas maintain fragmented but biodiverse forests. In term of Middle Narmada Basin, district like Bhopal (14 ha), Burhanpur (47 ha), Jhabu (1.3 ha) has comparatively lower dense forest area. Again it is to note that these district share a minimal area with Middle Narmada Basin (Figure 5).

Other Vegetation (Shrubs/Trees) category reveals the basin's ecological buffers. East Nimar (Khandwa) leads with 151,845 hectares of scattered vegetation, showing extensive areas in transition between forests and farms. West Nimar (147,487 ha) and Dewas (135,750 ha) demonstrate similar patterns of secondary growth. Nandurbar (84,026 ha) and Alirajpur (68,600 ha) maintain robust scrub forests crucial for tribal livelihoods. Barwani (110,780 ha) and Harda (81,970 ha) show how wastelands are being utilized for pasture. Tribal districts like Jhabua (72 ha) and Chhota Udepur (11,407 ha) reveal stark contrasts in vegetation management approaches.

#### **4.3. Flooded Vegetation**

The flooded vegetation data reveals crucial wetland ecosystems across the basin. East Nimar dominates with 177 hectares, primarily along the Narmada's floodplains near the Indira Sagar reservoir. Barwani (0.35 ha), Dhar (0.03 ha), and West Nimar (0.2 ha) show minimal but ecologically significant patches, likely seasonal marshes. Dewas (0.2 ha) and Sehore (1.1 ha) indicate small riparian zones along tributaries. Strikingly, 11 districts report no flooded vegetation, including forested Betul and agricultural Harda, suggesting no presence of larger water bodies (Figure 5).

#### **4.4. Agricultural Land**

The agricultural landscape shows the basin's economic backbone. West Nimar's massive 571,233 hectares of farmland showcase the Narmada valley's legendary fertility, followed closely by East Nimar (411,070 ha) and Dhar (379,674 ha) which form the region's grain basket. Dewas (204,779 ha), Harda (225,657 ha), and Barwani (266,145 ha) demonstrate successful adoption of irrigation and cash crops. Sehore (180,502 ha) and Hoshangabad (148,524 ha) maintain stable agricultural output despite undulating terrain (Figure 5). The smaller farming footprints in Betul (39,105 ha), Alirajpur (129,677 ha), and Nandurbar (65,693 ha) reflect more subsistence-based cultivation. At the extreme end, Raisen's mere 99

hectares of farmland Chhota Udepur (2,200 ha), and Narmada district (3,628 ha) show how mountainous landscapes and limit agricultural potential (Figure 6).

#### **4.5. Area Under Different Agricultural Land Revenue Categories**

The Middle Narmada Basin presents remarkable diversity in different land-revenue categories across its districts, reflecting varying ecological conditions, agricultural practices, and development pressures. A detailed examination of the land classification data reveals several critical trends and inter-district variations that are crucial for sustainable basin management. However, in this sections data is not limited to only basin boundaries but the data is for the whole district which comes under Narmada Basin.

Land Not Available for Cultivation which also include ‘area not available for agricultural uses’ and ‘barren/unculturable land’ presents a different pattern, with Dhar district topping the list at 135,062 hectares (including 76,001 ha of barren land), followed by Barwani (102,850 ha) and Khandwa (96,171 ha). In contrast, Burhanpur shows the most efficient land utilization with just 22,139 hectares classified as uncultivable, followed by Harda (21,070 ha) and Alirajpur (27,349 ha). The high values in Dhar and Barwani suggest significant land degradation that warrants immediate conservation attention.

Other Uncultivated Land including pastures, trees, culturable wasteland shows Khargone leading with 61,208 hectares (including 17,066 ha of culturable wasteland), followed by Dhar (55,773 ha) and Khandwa (39,767 ha). This category, comprising permanent pastures, grazing lands, and cultivable wasteland, represents both challenges and opportunities for land reclamation. The lowest values appear in Dhule (243 ha), Nandurbar (358 ha), and Harda (4,153 ha), indicating either intensive land use or potential data reporting issues that need verification.

Fallow Land patterns reveal Khandwa maintaining the highest area at 12,581 hectares, followed by Khargone (16,490 ha) and Dhar (7,368 ha), suggesting these districts practice more traditional crop rotation systems. The lowest fallow lands are found in Sehore (533 ha), Chhotaudepur (128 ha), and Jhabua (1,428 ha), indicating either continuous cropping pressure or different agricultural practices in these areas.

Net Sown Area highlights Dewas as the agricultural powerhouse with 417,599 hectares under cultivation, followed closely by Dhar (501,375 ha) and Khargone (411,753 ha), which together form the basin's most productive agricultural belt. At the opposite end, the Maharashtra border districts of Dhule (4,188 ha) and Nandurbar (2,406 ha) show minimal cultivation, along with Jhabua (183,087 ha), reflecting the challenges of tribal agriculture in less fertile areas.

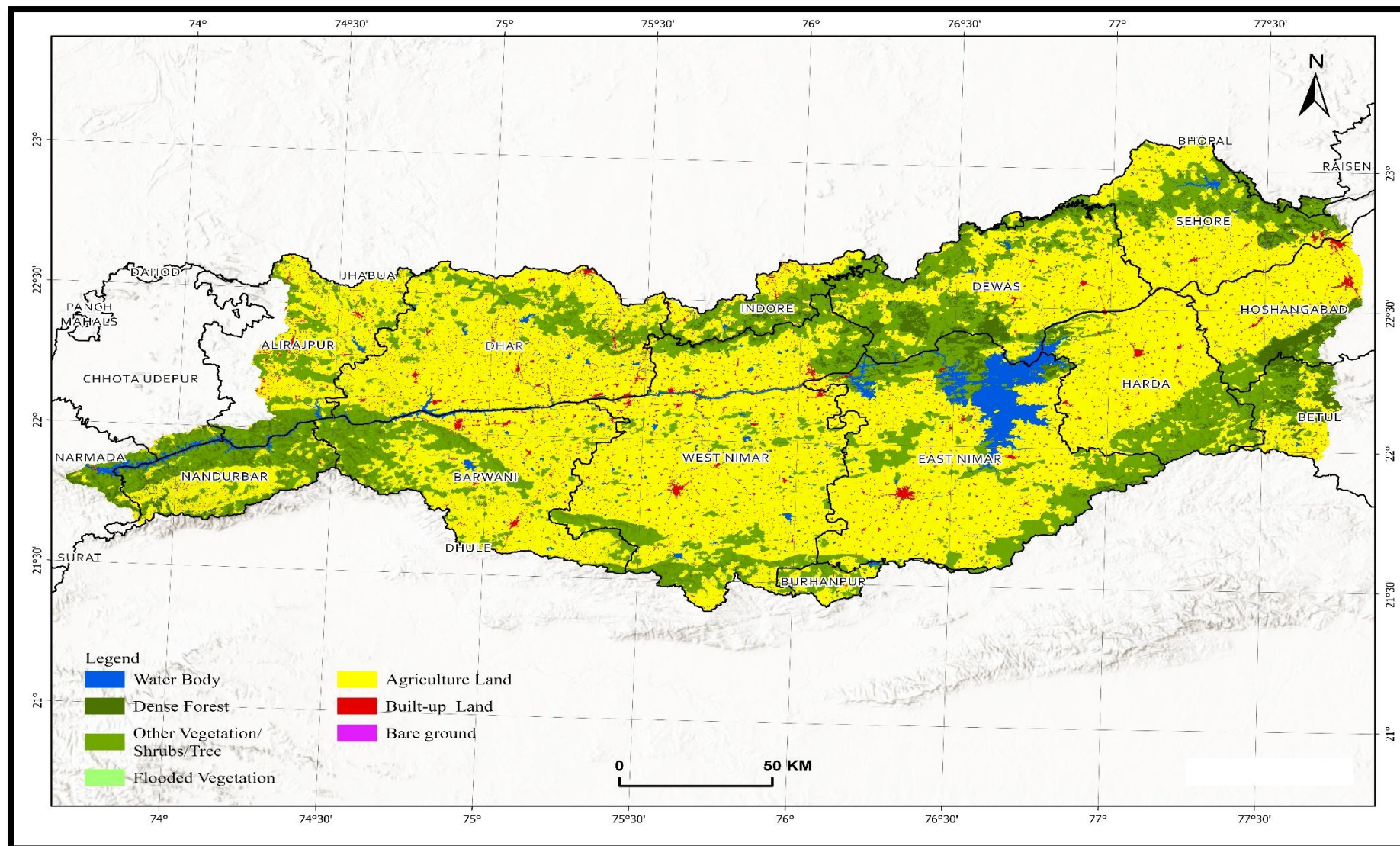
Cropping Intensity (area sown more than once) reveals Sehore's remarkable performance with 486,146 hectares cropped area (118% intensity), followed by Dewas (410,136 ha additional cropping) and Khargone (397,591 ha), demonstrating successful irrigation adoption in these districts. The lowest intensities appear in Dhule and Nandurbar (no data reported), with Chhotaudepur (43,971 ha additional cropping) showing moderate performance.

**Table 5. Classification of Land in Each District of Middle Narmada Basin for The Year 2022-2023 (Hectare)**

| District       | Classification of reporting Area |                                  |                              |                |                                               |                                             |                       |                |                                         |                |                  | Net Area Sown | Cropped Area | Area Sown More Than Once (14 - 13) |
|----------------|----------------------------------|----------------------------------|------------------------------|----------------|-----------------------------------------------|---------------------------------------------|-----------------------|----------------|-----------------------------------------|----------------|------------------|---------------|--------------|------------------------------------|
|                | Forests                          | Not available for Cultivation    |                              |                | Other Uncultivated Land Excluding Fallow Land |                                             |                       |                | Fallow Land                             |                |                  |               |              |                                    |
|                |                                  | Area under Non Agricultural Uses | Barren and Unculturable Land | Total (3 To 4) | Permanent Pasture and other Grazing Land      | Misc. Tree Crops and Groves not included in | Culturable waste Land | Total (6 To 8) | Fallow Lands other than current Fallows | Current Fallow | Total (10 To 11) |               |              |                                    |
| 1              | 2                                | 3                                | 4                            | 5              | 6                                             | 7                                           | 8                     | 9              | 10                                      | 11             | 12               | 13            | 14           | 15                                 |
| Madhya Pradesh |                                  |                                  |                              |                |                                               |                                             |                       |                |                                         |                |                  |               |              |                                    |
| Alirajpur      | 121395                           | 27349                            | 49117                        | 76466          | 3619                                          | -                                           | 9449                  | 13068          | 2592                                    | 634            | 3226             | 168504        | 234064       | 65560                              |
| Barwani        | 183067                           | 29430                            | 73420                        | 102850         | 9218                                          | -                                           | 2177                  | 11395          | 2396                                    | 975            | 3371             | 229163        | 387017       | 157854                             |
| Bhopal         | 44106                            | 38296                            | 8510                         | 46806          | 18487                                         | 228                                         | 1928                  | 20643          | 6753                                    | 5253           | 12006            | 154319        | 301886       | 147567                             |
| Burhanpur      | 202052                           | 16256                            | 5883                         | 22139          | 11586                                         | 65                                          | 1047                  | 12698          | 1669                                    | 1861           | 3530             | 102322        | 172725       | 70403                              |
| Dewas          | 206430                           | 36493                            | 10371                        | 46864          | 25437                                         | 25                                          | 2498                  | 27960          | 812                                     | 1642           | 2454             | 417599        | 827735       | 410136                             |
| Dhar           | 119963                           | 59061                            | 76001                        | 135062         | 44565                                         | 32                                          | 11176                 | 55773          | 4109                                    | 3259           | 7368             | 501375        | 989544       | 488169                             |
| Harda          | 103439                           | 17704                            | 3366                         | 21070          | 1951                                          | 45                                          | 2157                  | 4153           | 3777                                    | 4350           | 8127             | 193790        | 518740       | 324950                             |
| Indore         | 52208                            | 40239                            | 10869                        | 51108          | 15828                                         | 75                                          | 3785                  | 19688          | 4840                                    | 3463           | 8303             | 251790        | 495308       | 243518                             |
| Jhabua         | 10919                            | 32701                            | 36212                        | 68913          | 4021                                          | 63                                          | 23294                 | 27378          | 1428                                    | 1332           | 2760             | 183087        | 298443       | 115356                             |
| Khandwa        | 305323                           | 88793                            | 7378                         | 96171          | 39730                                         | 37                                          | -                     | 39767          | 10143                                   | 2438           | 12581            | 321774        | 604894       | 283120                             |
| Khargone       | 246852                           | 48150                            | 34204                        | 82354          | 44113                                         | 29                                          | 17066                 | 61208          | 12578                                   | 3912           | 16490            | 411753        | 809344       | 397591                             |
| Sehore         | 172582                           | 36918                            | 9586                         | 46504          | 21497                                         | 28                                          | 3385                  | 24910          | 474                                     | 59             | 533              | 411839        | 897985       | 486146                             |
| Gujarat        |                                  |                                  |                              |                |                                               |                                             |                       |                |                                         |                |                  |               |              |                                    |
| Chhotaudepur   | 64077                            | 33772                            | 9354                         | 43126          | 8704                                          | -                                           | 5016                  | 13720          | 128                                     | 7583           | 7711             | 219593        | 263564       | 43971                              |
| Maharashtra    |                                  |                                  |                              |                |                                               |                                             |                       |                |                                         |                |                  |               |              |                                    |
| Dhule          | 1844                             | 249                              | 549                          | 798            | 171                                           | 14                                          | 58                    | 243            | 111                                     | 145            | 256              | 4188          | -            | -                                  |
| Nandurbar      | 3734                             | 105                              | 362                          | 467            | 325                                           | 2                                           | 31                    | 358            | 67                                      | 18             | 85               | 2406          | -            | -                                  |

Source: Directorate of Economics & Statistics ((2022-2023), Land Use Statistics of respective states





**Figure 6. Middle Narmada Basin: Land Revenue Categories**

Source: Calculated from Sentinel, 2024

#### 4.6. Built-up Land

Urbanization patterns reveal the basin's development pressures. Dhar's 19,802 hectares of built-up area reflects its position in terms of towns. It is also noteworthy that district like Dhar, East Nimar and West Nimar shares a larger proportion of area with Middle Narmada Basin.

**Table 6. District-wise Land Revenue Categories of Middle Narmada Basin (in hectares)**

| Districts     | Water Body | Dense Forest | Flooded Vegetation | Agricultural Land | Built-up Land | Bare Ground | Other Vegetation/ Shrubs /Trees |
|---------------|------------|--------------|--------------------|-------------------|---------------|-------------|---------------------------------|
| Alirajpur     | 5289.11    | 1933.88      | NA                 | 129677.23         | 8083.06       | NA          | 68600.28                        |
| Barwani       | 8925.01    | 1303.67      | 0.35               | 266145.23         | 11111.51      | 0.41        | 110779.56                       |
| Betul         | 236.92     | 21358.16     | NA                 | 39105.04          | 1548.09       | NA          | 34885.64                        |
| Bhopal        | NA         | 13.59        | NA                 | 287.05            | 0.77          | NA          | 752.09                          |
| Burhanpur     | 742.1      | 47.03        | NA                 | 17038.4           | 303.14        | NA          | 19757.4                         |
| Dewas         | 8027.5     | 35408.54     | 0.212              | 204779.41         | 8142.06       | 2.73        | 135750.41                       |
| Dhar          | 12011.12   | 2772.17      | 0.028              | 379674.44         | 19801.83      | 10.54       | 79333.58                        |
| East Nimar    | 75081.46   | 18813.35     | 177.123            | 411069.86         | 16730.58      | 73.28       | 151845.2                        |
| Harda         | 4914.13    | 6975.22      | NA                 | 225656.98         | 8210.85       | 2.11        | 81970.49                        |
| Hoshangabad   | 1937.28    | 21405.87     | 0.046              | 148524.4          | 8066.81       | 181.15      | 23683.13                        |
| Indore        | 690.82     | 5223.65      | NA                 | 42543.04          | 3223.22       | 0.03        | 52293.93                        |
| Jhabua        | 5.52       | 1.28         | NA                 | 801.65            | 13.08         | NA          | 71.99                           |
| Raisen        | 16.74      | 3185.93      | NA                 | 99.19             | 24.9          | NA          | 7394.71                         |
| Sehore        | 5498.03    | 17750.48     | 1.138              | 180501.85         | 6772.44       | 26.15       | 82402.86                        |
| West Nimar    | 12653.86   | 9106.37      | 0.203              | 571233.29         | 22879.49      | 18.13       | 147487.04                       |
| Chhota Udepur | 2559.27    | 264.56       | NA                 | 2199.54           | 118.85        | NA          | 11407.42                        |
| Narmada       | 3879.6     | 1733.25      | 0.203              | 3627.71           | 207.04        | 4.89        | 18143.78                        |
| Dhule         | NA         | 2.25         | NA                 | 144.71            | 10.14         | NA          | 690.34                          |
| Nandurbar     | 6036.12    | 5425.22      | NA                 | 65692.73          | 1010.51       | NA          | 84025.58                        |

*Source: Authors' Calculation based on Sentinel Data, 2024,*

*NA shows that very small part of a district comes under Middle Narmada Basin and that particular area does not have significant water bodies*

Although Indore is a metropolitan city, it has only 3223.22 ha area which less in compare to other less urbanised districts. This is because the metropolitan city does not fall under the Narmada River Basin but Indore district share a proportion of its area with Middle Narmada



Basin. West Nimar (22,879 ha) and East Nimar (16,731 ha) show a significant presence of built-up land along industrial corridors. Alirajpur (8,083 ha), Barwani (11,112 ha), and Dewas (8,142 ha) demonstrate how smaller towns are expanding with improved connectivity. Harda (8,211 ha) and Hoshangabad (8,067 ha) maintain moderate built-up area balanced with agriculture. The surprisingly low figures in Bhopal (0.8 ha) and Raisen (25 ha) clearly indicate data reporting issues rather than actual patterns. Tribal districts like Jhabua (13 ha), Narmada (207 ha), and Chhota Udepur (119 ha) retain their rural character despite being district headquarters (Figure 6).

#### **4.7. Bare Ground**

The bare ground data indicates erosion and land degradation hotspots or weathering areas. Hoshangabad's 181 hectares of exposed land reveal vulnerable areas near the Vindhyan scarps. East Nimar (73 ha) and Sehore (26 ha) show moderate exposure, likely in rainfed agricultural zones. West Nimar (18 ha) and Dhar (11 ha) maintain better ground cover through conservation practices. Most districts like Betul, Alirajpur, and Harda report negligible bare ground (0-2 ha), suggesting good vegetative protection. The complete absence of data in many districts suggests either excellent land management or reporting gaps that need verification through ground surveys.

### **5. Lower Narmada Basin: Land Revenue Categories**

Lower Narmada Basin mostly constitutes parts of Gujarat following Madhya Pradesh and a few districts of Maharashtra. This part of Narmada River Basin holds nearly 65 percent agricultural land to the total area of Lower Basin which second to the Middle Narmada River Basin. Apart from the agricultural land, Middle Narmada Basin also holds a significant portion in the forest and vegetation categories (25%) which is the second largest land revenue

category after the agricultural land (Table 2). Figure 7 shows district wise distribution of various land-revenue categories and these observations are shown in detail in the Table 7.

### **5.1. Water Bodies**

The water resources in the Lower Narmada Basin show significant variation across districts. Bharuch leads with 7,510 hectares of water bodies, benefiting from its position at the Narmada estuary where the river meets the Arabian Sea. Narmada district follows closely with 5,898 hectares, supported by the Sardar Sarovar Dam and its reservoir. Chhota Udepur (4,204 ha) and Vadodara (1,805 ha) show moderate water availability from tributaries and medium irrigation projects. Surprisingly, Surat (46 ha), and Dahod (6 ha), and demonstrate less water bodies and that is because of their tiny proportion of the are under Lower Narmada Basin. Panch Mahals (98 ha) and Alirajpur (203 ha) maintain minimal but critical water resources for local communities.

### **5.2. Dense Forests and Other Vegetation**

Narmada district dominates with 14,590 hectares of dense forests, protected under the Shoolpaneshwar Wildlife Sanctuary. Chhota Udepur (7,540 ha) and Bharuch (4,104 ha) form important forest corridors connecting the Satpura and Western Ghats ecosystems. Alirajpur (10,711 ha) shows robust forest cover despite being a tribal-dominated region. The shockingly low figures in Surat (1,288 ha), Vadodara (1,972 ha), and Nandurbar (56 ha) reveal intense pressure from urbanization and industrialization. Dahod (1,699 ha) and Panch Mahals (1,474 ha) maintain fragmented but biodiverse forest patches crucial for tribal livelihoods.

Other Vegetation (Shrubs/Trees) shows that Alirajpur dominates with 55,456 hectares of scrubland, crucial for tribal livelihoods. Chhota Udepur (60,891 ha) and Narmada district (49,274 ha) maintain robust secondary growth. Bharuch (24,264 ha) shows how wastelands

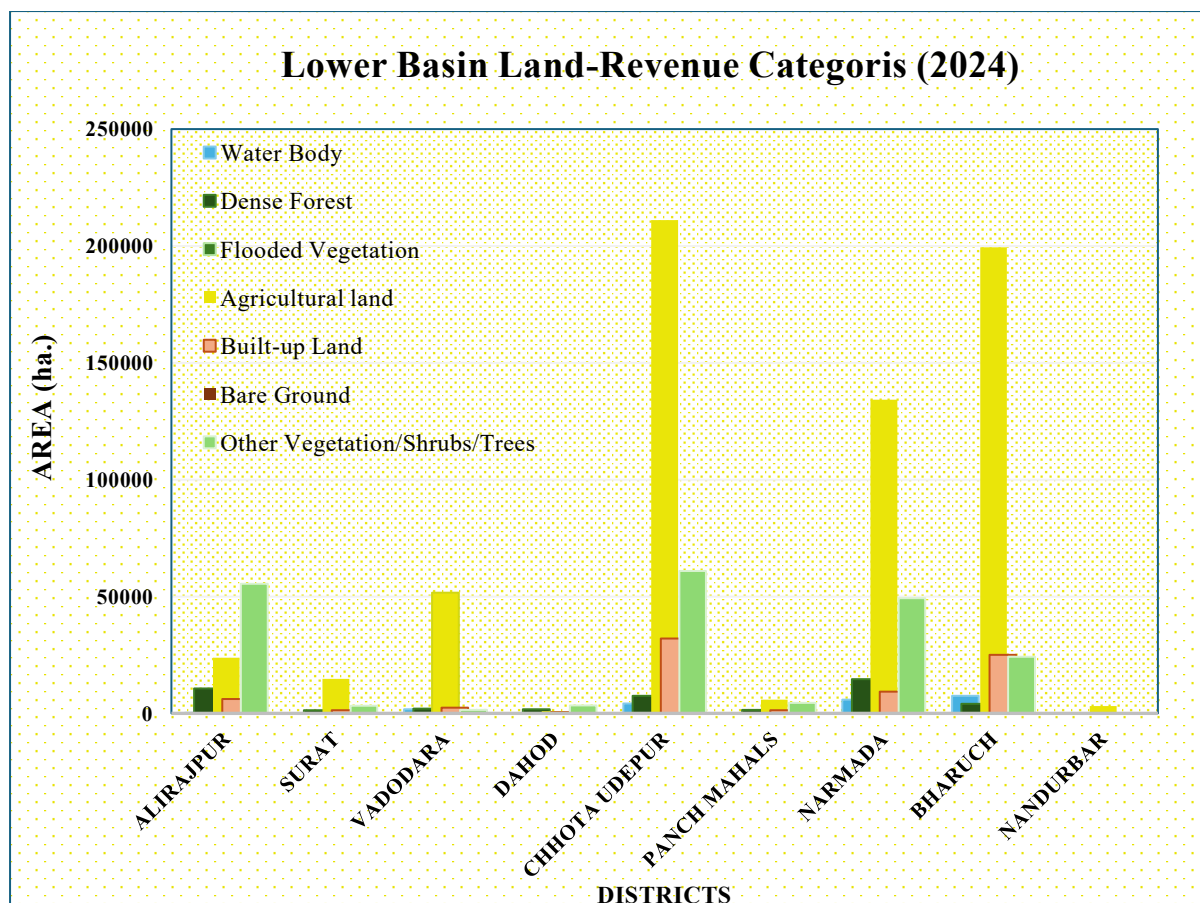
are being utilized for pasture. Vadodara's unusual pattern (1,536 ha) versus neighbouring districts suggests potential data inconsistencies.

***Table 7. District-wise Land Revenue Categories of Lower Narmada Basin (in hectares)***

| <b>District</b>      | <b>Water Body</b> | <b>Dense Forest</b> | <b>Flooded Vegetation</b> | <b>Agricultural Land</b> | <b>Built-up Land</b> | <b>Bare Ground</b> | <b>Other Vegetation/ Shrubs/ Trees</b> |
|----------------------|-------------------|---------------------|---------------------------|--------------------------|----------------------|--------------------|----------------------------------------|
| <b>Alirajpur</b>     | 203.18            | 10711.03            | NA                        | 23844.25                 | 6127.30              | NA                 | 55455.93                               |
| <b>Surat</b>         | 45.74             | 1287.86             | NA                        | 14743.40                 | 1383.68              | NA                 | 3243.36                                |
| <b>Vadodara</b>      | 1805.06           | 1972.34             | NA                        | 51639.96                 | 2470.56              | 150.11             | 1536.24                                |
| <b>Dahod</b>         | 5.88              | 1699.07             | NA                        | 954.84                   | 491.90               | NA                 | 3411.81                                |
| <b>Chhota Udepur</b> | 4203.58           | 7540.34             | 45.96                     | 211096.49                | 31974.62             | 265.07             | 60891.25                               |
| <b>Panch Mahals</b>  | 97.97             | 1473.61             | NA                        | 5904.56                  | 1341.45              | NA                 | 4564.30                                |
| <b>Narmada</b>       | 5897.73           | 14590.42            | 0.17                      | 134173.68                | 9305.86              | 83.95              | 49274.41                               |
| <b>Bharuch</b>       | 7510.36           | 4103.92             | 61.64                     | 199382.86                | 25114.04             | 307.23             | 24263.81                               |
| <b>Nandurbar</b>     | NA                | 56.21               | NA                        | 3097.79                  | 133.92               | NA                 | 23.85                                  |

*Source: Authors' Calculation based on Sentinel Data, 2024,*

*NA shows that very small part of a district comes under Middle Narmada Basin and that particular area does not have significant water bodies*



**Figure 7. Lower Basin: District-wise Land-revenue Categories**

Source: Calculated from Sentinel, 2024

### 5.3. Flooded Vegetation

In this category only a few districts have significant data on flooded vegetation as other districts less proportion of their area and that portion does not have larger water bodies surrounded by flooded vegetation. However, Bharuch stands out with 62 hectares of flooded vegetation, primarily in the estuarine wetlands of the Narmada delta. Chhota Udepur reports 46 hectares, likely seasonal marshes along the Orsang river. Narmada district shows minimal coverage (0.17 ha), suggesting alteration of natural floodplains by dam operations.

### 5.4. Agricultural Land

Chhota Udepur emerges as the agricultural leader with 211,096 hectares under cultivation, leveraging the fertile plains of the Narmada and Orsang rivers. Bharuch follows closely with 199,383 hectares, including the famous 'Golden Corridor' of Gujarat. Narmada district

(134,174 ha) and Vadodara (51,640 ha) demonstrate successful irrigation adoption. The low figures in Dahod (955 ha) and Nandurbar (3,098 ha) likely reflect topographic constraints in these hilly tribal districts. Panch Mahals (5,905 ha) and Surat (14,743 ha) show moderate but stable agricultural activity (Table 7).

### **5.5. Area Under Different Agricultural Land Revenue Categories**

Table 8 reveals contrasts in land quality across the basin. Bharuch presents the most challenging scenario with 101,455 hectares classified as uncultivable - including a remarkable 84,600 hectares under non-agricultural uses. This reflects, likely, the district's industrial character, with major petroleum, chemical, and port facilities occupying substantial areas, compounded by salinity intrusion in coastal tracts. Vadodara follows with 63,198 hectares of not cultivable land, while Surat's 67,991 hectares indicate similar pressures from urbanization and industrial development. In contrast, the more interior districts show better land potential - Narmada with 40,183 hectares and Dohad with just 31,614 hectares of uncultivable land, suggesting these areas retain higher agricultural viability. The difference in areas are also because of their share to the Lower Narmada Basin.

In the 'Other Uncultivated Land Excluding Fallow Land' permanent pastures are most extensive in Bharuch (14,271 hectares), supporting livestock rearing, while Narmada district has the smallest area (8,103 hectares) dedicated to grazing. Land under miscellaneous tree crops is notably high in Panch Mahals (1,413 hectares), showcasing agroforestry practices, but absent in Dohad. Culturable wasteland reaches its peak in Bharuch (44,070 hectares), indicating reclamation potential, with Narmada district having the least (4,861 hectares) of such underutilized land. The total uncultivated land is greatest in Bharuch (59,812 hectares) and least in Narmada (13,086 hectares), revealing district-level disparities in land development.

Fallow lands other than current fallows are most prevalent in Bharuch (12,375 hectares), suggesting crop rotation practices, while Vadodara shows minimal such areas (4,235 hectares). Current fallow land is exceptionally high in Surat (46,617 hectares), likely due to seasonal waterlogging, compared to Vadodara's modest 1,652 hectares. Total fallow land consequently peaks in Surat (48,813 hectares) and reaches its lowest in Vadodara (5,887 hectares), highlighting varying agricultural intensities across the region.

Vadodara leads in 'net sown area' (292,826 hectares), benefiting from Narmada canal irrigation, while Narmada district has the smallest (115,884 hectares) due to topographical constraints. This reflects the agricultural productivity gradient from the interior plains to the coastal reaches of the basin.

Under 'cropped area', Dohad demonstrates the highest cropped area (397,045 hectares), achieving impressive double cropping, with Narmada district showing the most modest expansion (141,542 hectares) beyond net sown area. This variation underscores differences in irrigation availability and farming practices across districts.

In terms of 'area sown more than once', Dohad's exceptional performance (174,059 hectares) in multiple cropping contrasts sharply with Narmada district's limited capacity (25,658 hectares) for repeat sowing, revealing the irrigation advantage of eastern districts over western coastal areas in the lower basin. Vadodara's intermediate position (70,972 hectares) indicates partial coverage under canal irrigation systems.

## **5.6. Built-up Land**

Chhota Udepur's 31,975 hectares of built-up area reflect higher urbanization near the Chhota Udaipur city. Bharuch follows with 25,114 hectares, driven by industrial growth along the Delhi-Mumbai corridor. Narmada district (9,306 ha) shows development around the Sardar Sarovar dam site. Urban centers like Vadodara (2,471 ha) and Surat (1,384 ha) report

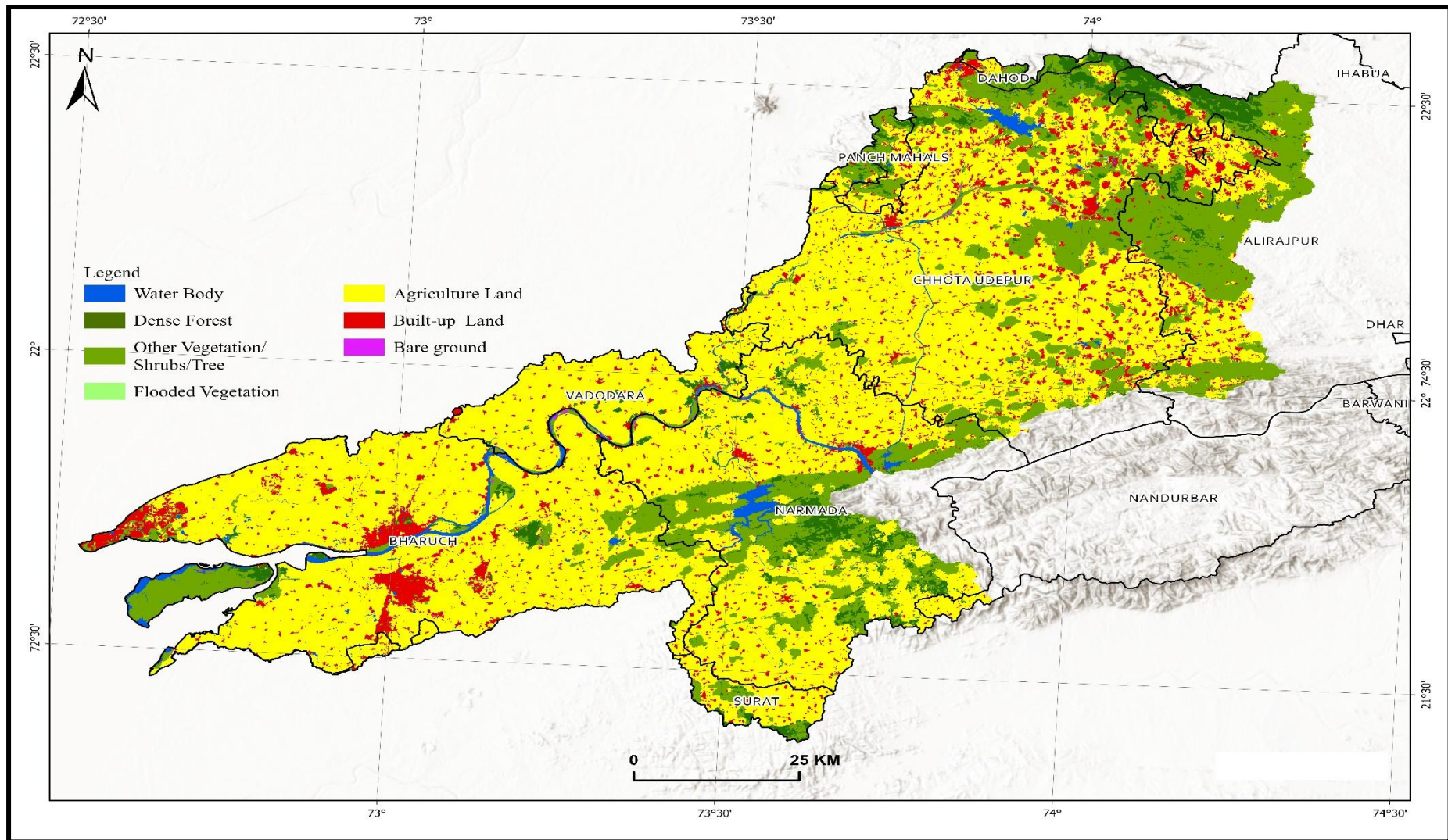
surprisingly low figures, suggesting that municipal boundaries fall out of the Lower Narmada Basin. The tribal districts of Dahod (492 ha), Panch Mahals (1,341 ha), and Nandurbar (134 ha) maintain their rural character.

**Table 8. Classification of Land in Each District of Lower Narmada Basin for The Year 2020-2021 (Hectare)**

| Classification of Land in Each District of Lower Narmada Basin for The Year 2020-2021 (Hectare) |                                  |                                  |                              |                |                                               |                                                                      |                       |                |                                         |                |                  |               |              |                                       |
|-------------------------------------------------------------------------------------------------|----------------------------------|----------------------------------|------------------------------|----------------|-----------------------------------------------|----------------------------------------------------------------------|-----------------------|----------------|-----------------------------------------|----------------|------------------|---------------|--------------|---------------------------------------|
| District                                                                                        | Classification of reporting Area |                                  |                              |                |                                               |                                                                      |                       |                |                                         |                |                  | Net Area Sown | Cropped Area | Area Sown More Than Once<br>(14 - 13) |
|                                                                                                 | Forests                          | Not available for Cultivation    |                              |                | Other Uncultivated Land Excluding Fallow Land |                                                                      |                       |                | Fallow Land                             |                |                  |               |              |                                       |
|                                                                                                 |                                  | Area under Non Agricultural Uses | Barren and Unculturable Land | Total (3 To 4) | Permanent Pasture and other Grazing Land      | Land under Misc. Tree Crops and Groves not included in Net Area Sown | Culturable waste Land | Total (6 To 8) | Fallow Lands other than current Fallows | Current Fallow | Total (10 To 11) |               |              |                                       |
| 1                                                                                               | 2                                | 3                                | 4                            | 5              | 6                                             | 7                                                                    | 8                     | 9              | 10                                      | 11             | 12               | 13            | 14           | 15                                    |
| Gujarat                                                                                         |                                  |                                  |                              |                |                                               |                                                                      |                       |                |                                         |                |                  |               |              |                                       |
| Bharuch                                                                                         | 22319                            | 84600                            | 16855                        | 101455         | 14271                                         | 1471                                                                 | 44070                 | 59812          | 12375                                   | 17194          | 29569            | 307002        | 330757       | 23755                                 |
| Dohad                                                                                           | 91820                            | 20524                            | 11090                        | 31614          | 8444                                          | -                                                                    | 6317                  | 14761          | 812                                     | 2155           | 2967             | 222986        | 397045       | 174059                                |
| Narmada                                                                                         | 105629                           | 32099                            | 8084                         | 40183          | 8103                                          | 122                                                                  | 4861                  | 13086          | 2994                                    | 3725           | 6719             | 115884        | 141542       | 25658                                 |
| Panch mahals                                                                                    | 68507                            | 41071                            | 8386                         | 49457          | 11203                                         | 1413                                                                 | 6368                  | 18984          | 4149                                    | 7758           | 11907            | 179240        | 233864       | 54624                                 |
| Surat                                                                                           | 54762                            | 52724                            | 15267                        | 67991          | 17671                                         | 1157                                                                 | 24544                 | 43372          | 2196                                    | 46617          | 48813            | 219026        | 240468       | 21442                                 |
| Vadodara                                                                                        | 14420                            | 48193                            | 15005                        | 63198          | 19529                                         | 208                                                                  | 11637                 | 31374          | 4235                                    | 1652           | 5887             | 292826        | 363798       | 70972                                 |

Source: Directorate of Economics & Statistics, Land Use Statistics Gujarat (2020-2021)





**Figure 8. Lower Narmada Basin: Land Revenue Categories**

Source: Calculated from Sentinel, 2024

## 5.7. Bare Ground

Bharuch leads with 307 hectares of exposed land, likely in industrial zones and mining areas. Vadodara follows with 150 hectares, showing pressure from urban expansion. Chhota Udepur (265 ha) and Narmada district (84 ha) demonstrate moderate land degradation.

## 6. Land-to-People Ratio (LtPR)

The land-to-people ratio (LtPR), which measures the availability of land per capita, is a critical metric for understanding resource pressure, livelihood sustainability, and economic potential in a river basin. A high ratio (more land per person) often indicates lower population density, allowing for extensive agriculture, forest conservation, and lower competition for water resources. Conversely, a low ratio (less land per person) signals higher population pressure, leading to land fragmentation, intensive farming, and potential overexploitation of water and soil resources. In revenue mapping, this ratio helps identify regions where land productivity must be maximized to support livelihoods, as well as areas where land degradation risks are high due to overuse. For river basins, it also highlights disparities in water access—downstream areas with dense populations may face greater water stress compared to upstream regions. By integrating land-people ratios with revenue data, policymakers can prioritize equitable water distribution, sustainable land-use planning, and targeted agricultural subsidies, ensuring balanced economic growth while preserving ecological health across the basin.

The comprehensive LtPR assessment offers valuable insights into the region's ecological condition, agricultural prospects, and socio-economic challenges. Table 9, Table 10 and Table 11 show district wise per capita land availability of Upper, Middle and Lower Narmada Basin. The last column of the tables shows district wise comparative high and low land availability for each class. Additionally red colour for each class shows if there is higher pressure of population on that particular class. Green class shows moderate and white low pressure of population on the resources. However, in case of fallow land category red shows high availability of the fallow land but it has been flagged as red because it shows that in that class, crop intensity is low and agricultural land is not in proper use due to different regions

## 6.1. Upper Narmada Basin LtPR

The Upper Narmada Basin, stretching across Madhya Pradesh and Chhattisgarh, showcases significant diversity in land availability and utilization patterns, as highlighted by the Land-to-People Ratio (LtPR) analysis (Table 9).

### 6.1.1 Forest LtPR

The forest LtPR shows extreme variation across the basin. Mandla district emerges as the clear leader with an exceptional ratio of 0.562 hectares of forest per person, followed by Umaria (0.367) and Balaghat (0.297). The high ratios suggest a low pressure on forests under these districts. At the opposite end, Jabalpur (0.032), Rajnandgaon (0.053), and Dindori (0.036) present concerningly low forest availability per capita. Jabalpur's minimal ratio reflects its urban character and industrial development, while Rajnandgaon's poor showing indicates significant pressure on forest resources (Table 9). Dindori's low ratio despite its tribal-dominated landscape is noteworthy.

**Table 9. Land-to-People Ratio in Upper Narmada Basin Lower Basin, (ha per capita)**

| Districts   | Forest LtPR | Not Cultivable LtPR | Fallow LandLtPR | Net Area Sown LtPR | Cropped Area LtPR | Sown More Than Once LtPR | Ratio Comparision |
|-------------|-------------|---------------------|-----------------|--------------------|-------------------|--------------------------|-------------------|
| Anuppur     | 0.102       | 0.077               | 0.064           | 0.215              | 0.299             | 0.084                    |                   |
| Balaghat    | 0.297       | 0.033               | 0.009           | 0.183              | 0.268             | 0.085                    |                   |
| Betul       | 0.251       | 0.039               | 0.012           | 0.296              | 0.531             | 0.235                    |                   |
| Chhindwara  | 0.228       | 0.034               | 0.022           | 0.242              | 0.446             | 0.204                    |                   |
| Damoh       | 0.211       | 0.073               | 0.005           | 0.256              | 0.499             | 0.243                    |                   |
| Dindori     | 0.036       | 0.057               | 0.064           | 0.313              | 0.479             | 0.166                    |                   |
| Hoshangabad | 0.206       | 0.037               | 0.005           | 0.263              | 0.745             | 0.482                    |                   |
| Jabalpur    | 0.032       | 0.033               | 0.009           | 0.111              | 0.253             | 0.142                    |                   |
| Katni       | 0.077       | 0.053               | 0.017           | 0.183              | 0.337             | 0.154                    |                   |
| Mandla      | 0.562       | 0.053               | 0.036           | 0.221              | 0.375             | 0.154                    |                   |
| Narsimhapur | 0.125       | 0.020               | 0.006           | 0.291              | 0.570             | 0.279                    |                   |
| Raisen      | 0.251       | 0.034               | 0.004           | 0.322              | 0.601             | 0.279                    |                   |
| Sagar       | 0.125       | 0.030               | 0.007           | 0.234              | 0.463             | 0.228                    |                   |
| Seoni       | 0.238       | 0.045               | 0.020           | 0.300              | 0.551             | 0.252                    |                   |
| Umaria      | 0.367       | 0.060               | 0.031           | 0.192              | 0.332             | 0.141                    |                   |
| Kabeerdham  | 0.230       | 0.032               | 0.011           | 0.227              | 0.361             | 0.134                    |                   |
| Rajnandgaon | 0.053       | 0.021               | 0.010           | 0.119              | 0.166             | 0.048                    |                   |

Source: Authors' Calculation based on Madhya Pradesh and Chhattisgarh Directorate of Economics & Statistics, Land Use Statistics (2022-23)

### **6.1.2 Non-Cultivable Land LtPR**

The non-cultivable land LtPR reveals distinct patterns and alternative uses. Anuppur (0.077) tops this category, indicating significant land unsuitable for agriculture, likely due to rocky terrain or mining activities. Damoh (0.073) and Umaria (0.060) follow, showing similar challenges with marginal lands. The most favorable ratios appear in Narsimhapur (0.020), Sagar (0.030), and Balaghat (0.033), suggesting efficient land use and minimal wastage. These districts demonstrate how proper land management can maximize agricultural potential. Intermediate districts like Katni (0.053) and Mandla (0.053) maintain balanced ratios, indicating moderate levels of unproductive land.

### **6.1.3 Fallow Land LtPR**

Fallow land patterns provide insights into agricultural practices across the basin. Anuppur and Dindori share the highest ratio (0.064), reflecting traditional farming systems with extended fallow periods for soil recovery. This practice, while beneficial for land regeneration, may indicate lower agricultural productivity. In contrast, Raisen (0.004), Damoh (0.005), and Hoshangabad (0.005) show minimal fallow land, suggesting intensive, possibly irrigation-supported continuous cropping systems.

### **6.1.4 Net Sown Area LtPR**

The net area sown LtPR highlights the basin's agricultural core. Raisen (0.322) leads with the highest availability of cultivated land per person, followed by Dindori (0.313) and Seoni (0.300). These districts form the agricultural backbone of the region, supporting food security and rural livelihoods. At the other extreme, Jabalpur (0.111), Rajnandgaon (0.119), and Balaghat (0.183) show constrained agricultural land availability. For Jabalpur, urbanization is the likely constraint, while Rajnandgaon's poor showing may reflect topographical limitations. Balaghat's position is surprising given its forest wealth, suggesting potential trade-offs between conservation and agriculture.

### **6.1.5 Area Sown More Than Once LtPR**

The cropped area and multiple cropping ratios reveal the basin's agricultural efficiency. Hoshangabad stands out dramatically with 0.745 hectares cropped area and 0.482 hectares sown more than once per person, indicating highly productive, possibly irrigation-intensive systems. Raisen (0.601, 0.279) and Seoni (0.551, 0.252) follow, demonstrating successful agricultural intensification. The lowest ratios appear in Rajnandgaon (0.166, 0.048), Jabalpur (0.253, 0.142), and Kabeerdham (0.361, 0.134), highlighting areas where agricultural potential remains underdeveloped due to water limitations, poor infrastructure, or other constraints.

## **6.2. Middle Narmada Basin LtPR**

Middle Narmada Basin is spread over Madhya Pradesh, Gujrat and Maharashtra. Table 10 shows district wise LtPR of different classes in detail with the highs and lows values to the respective districts' classes.

### **6.2.1 Forest LtPR Patterns**

The basin reveals noticeable contrasts in forest resource distribution. Burhanpur emerges as the leader with 0.267 hectares of forest per person, followed closely by Khandwa (0.233) and Harda (0.181). These districts benefit from contiguous forest corridors along the Satpura ranges. At the opposite spectrum, urban centers like Bhopal (0.019) and Indore (0.016) show severe status of LtPR, while border districts Dhule (0.001) and Nandurbar (0.002) report extremely sever LtPR in terms of forest resources per capita, highlighting acute ecological stress in these regions.

### **6.2.2 Not Cultivable LtPR**

Alirajpur tops this category with 0.105 hectares of unproductive land per person, reflecting its challenging terrain of rocky outcrops and seasonal streams. Barwani (0.074) and Khandwa (0.073) follow, showing similar land constraints. Strikingly, Dhule and Nandurbar report



negligible values, suggesting either superior land quality or potential data reporting gaps that warrant verification. The relatively lower ratios in Dewas (0.030) and Sehore (0.035) demonstrate effective land utilization practices in these agriculturally advanced districts.

**Table 10. Land-to-People Ratio in Middle Narmada Basin Lower Basin, (ha per capita)**

| Districts | Forest LtPR | Not Cultivable LtPR | Fallow LandLtPR | Net Area Sown LtPR | Cropped Area LtPR | Sown More Than Once LtPR | Ratio Comparision |
|-----------|-------------|---------------------|-----------------|--------------------|-------------------|--------------------------|-------------------|
| Alirajpur | 0.167       | 0.105               | 0.004           | 0.231              | 0.321             | 0.090                    |                   |
| Barwani   | 0.132       | 0.074               | 0.002           | 0.165              | 0.279             | 0.114                    |                   |
| Bhopal    | 0.019       | 0.020               | 0.005           | 0.065              | 0.127             | 0.062                    |                   |
| Burhanpur | 0.267       | 0.029               | 0.005           | 0.135              | 0.228             | 0.093                    |                   |
| Dewas     | 0.132       | 0.030               | 0.002           | 0.267              | 0.529             | 0.262                    |                   |
| Dhar      | 0.055       | 0.062               | 0.003           | 0.229              | 0.453             | 0.223                    |                   |
| Harda     | 0.181       | 0.037               | 0.014           | 0.340              | 0.909             | 0.570                    |                   |
| Indore    | 0.016       | 0.016               | 0.003           | 0.077              | 0.151             | 0.074                    |                   |
| Jhabua    | 0.011       | 0.067               | 0.003           | 0.179              | 0.291             | 0.113                    |                   |
| Khandwa   | 0.233       | 0.073               | 0.010           | 0.246              | 0.462             | 0.216                    |                   |
| Khargone  | 0.132       | 0.044               | 0.009           | 0.220              | 0.432             | 0.212                    |                   |
| Sehore    | 0.132       | 0.035               | 0.000           | 0.314              | 0.685             | 0.371                    |                   |
| Dhule     | 0.001       | 0.000               | 0.000           | 0.002              | -                 | -                        |                   |
| Nandurbar | 0.002       | 0.000               | 0.000           | 0.001              | -                 | -                        |                   |

Source: Authors' Calculation based on Madhya Pradesh and Maharashtra Directorate of Economics & Statistics, Land Use Statistics (2022-23)

### 6.2.3 Fallow Land LtPR

In terms of fallow land LtPR, Harda stands apart with 0.014 hectares per person, indicating comparatively insignificant use of agricultural land. Most districts maintain modest fallow ratios between 0.002-0.005, suggesting intensive land use patterns. A few district like Sehore, Dhule and Nandurbar shows zero values, however actually values are 4 to 5 decimals that's why they are no displayed in the table. This means that the fallow land LtPR is extremely low in these districts and that is a sign of intensive use of agricultural land.

### 6.2.4 Net Sown Area LtPR

In context of net sown area LtPR, Sehore dominates with 0.314 hectares of cultivated land per capita, leveraging its fertile soils and irrigation infrastructure. Harda (0.340) and Dewas (0.267) complete the top three, forming the agricultural core of the basin. Urban districts

naturally trail, with Bhopal (0.065) and Indore (0.077) showing how urbanization constrains farmland availability.

### 6.2.5 Area Sown More Than Once

Harda's exceptional 0.570 ratio for multiple cropping demonstrates successful intensive use of agricultural land. Sehore (0.371) and Dewas (0.262) follow, showcasing the productivity potential of the Malwa plateau. The data unavailability for the same year as for other districts for Dhule and Nandurbar, prevents meaningful comparison, while Jhabua's moderate 0.113 ratio reflects the challenges of tribal agriculture in hilly terrain.

### 6.3. Lower Narmada Basin LtPR

Lower Narmada Basin covers districts of Gujrat, Madhya Pradesh and Maharashtra. Since most of the Lower Narmada Basin falls within the state of Gujarat, and basin-level statistics are unavailable for districts of Madhya Pradesh, this section, this report only considers the districts of Gujarat. Table 10 shows district wise LtPR of different classes in detail with the highs and lows values to the respective districts' classes.

**Table 11. Land-to-People Ratio in Lower Narmada Basin Lower Basin, (ha per capita)**

| Districts    | Forest LtPR | Not Cultivable LtPR | Fallow Land LtPR | Net Area Sown LtPR | Cropped Area LtPR | Sown More Than Once LtPR | Ratio Comparision |
|--------------|-------------|---------------------|------------------|--------------------|-------------------|--------------------------|-------------------|
| Bharuch      | 0.014       | 0.065               | 0.019            | 0.198              | 0.213             | 0.015                    |                   |
| Dohad        | 0.043       | 0.015               | 0.001            | 0.105              | 0.187             | 0.082                    |                   |
| Narmada      | 0.179       | 0.068               | 0.011            | 0.196              | 0.240             | 0.043                    |                   |
| Panch mahals | 0.029       | 0.021               | 0.005            | 0.075              | 0.098             | 0.023                    |                   |
| Surat        | 0.009       | 0.011               | 0.008            | 0.036              | 0.040             | 0.004                    |                   |
| Vadodara     | 0.003       | 0.015               | 0.001            | 0.070              | 0.087             | 0.017                    |                   |

Source: Authors' Calculation based on Gujrat Directorate of Economics & Statistics, Land Use Statistics (2020-21)

#### 6.3.1 Forest LtPR

Narmada district leads with 0.179 ha/person, reflecting its forested riparian zones near the Sardar Sarovar Dam. Dohad (0.043) and Panch Mahals (0.029) show moderate forest cover,

while Bharuch (0.014), Surat (0.009), and Vadodara (0.003) face severe in terms of LtPR due to urbanization and industrial expansion in these districts.

### **6.3.2 Not Cultivable LtPR**

Bharuch tops this category (0.065 ha/person), driven by industrial land use and saline ingress. Narmada (0.068) follows closely, likely due to rocky terrain, while Surat (0.011) and Vadodara (0.015) show minimal uncultivable land, indicating efficient urban planning or data gaps.

### **6.3.3 Fallow Land LtPR**

Bharuch again leads (0.019), suggesting crop rotation or land fragmentation, while Surat (0.008) and Panch Mahals (0.005) show limited fallow use. Dohad and Vadodara (0.001 each) reveal intensive farming with negligible fallow periods, risking soil health.

### **6.3.4 Net Area Sown LtPR**

Narmada (0.196) and Bharuch (0.198) dominate, leveraging fertile alluvial plains. Dohad (0.105) and Panch Mahals (0.075) lag due to hilly terrain, while Surat (0.036) and Vadodara (0.070) suffer from urban encroachment on farmland.

### **6.3.5 Cropping Intensity**

Dohad excels in cropped area (0.187) and double sowing (0.082), indicating irrigation access. Narmada (0.240 cropped, 0.043 double-sown) and Bharuch (0.213, 0.015) show moderate intensity. Surat (0.040, 0.004) and Vadodara (0.087, 0.017) perform poorly, constrained by urban sprawl.

## **7. Vulnerable Areas**

Mapping of land revenue categories is closely related to vulnerable or areas of over exploitation as it helps identify the economic impacts of degraded lands on local and national economies. By analyzing revenue streams from agriculture, forestry, and other land-based



activities (as discussed in previous sections), revenue mapping can highlight how vulnerable areas reduces productivity, leading to income losses for communities and governments. This data can guide policymakers in implementing sustainable land management practices, incentivizing restoration efforts, and allocating funds to combat degradation.

This section utilises land degradation, as a proxy of vulnerable area, web services provide by Bhuvan (<https://bhuvan-app1.nrsc.gov.in/thematic/thematic/index.php>) for the year 2015-16 to observe status of land degradation in the various parts of the basin.

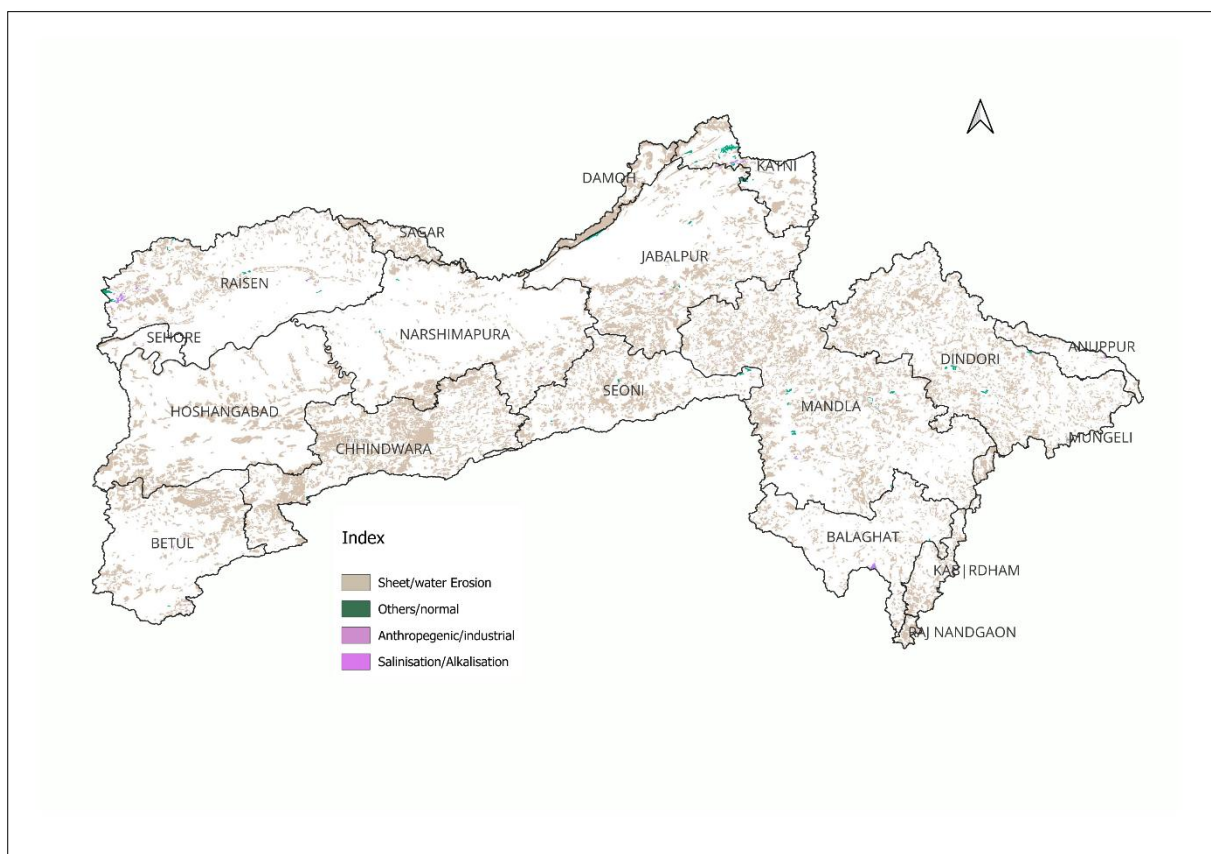
### **7.1. Upper Narmada Basin**

The map of the Upper Narmada Basin (Figure 9) highlights the spatial distribution of erosion patterns across various districts, categorizing them into three types: Sheet/Water Erosion, Others/normal erosion, Salinisation/alkalinisation and Anthropogenic/Industrial Erosion. Among these, sheet or water erosion, marked in beige, is the most prevalent and widespread form of erosion observed across the basin. This type of erosion is especially prominent in the districts of Chhindwara, Seoni, Mandla, Jabalpur, Narsinghpur, and Betul. The dominance of sheet erosion in these areas can be attributed to several interrelated factors. The topography of the region, characterized by hilly and undulating terrain. Also, the Upper Narmada Basin experiences substantial rainfall, especially during the monsoon season, which further intensifies the process of sheet erosion.

Others/normal erosion, marked in green on the map, appears to be less widespread and is confined to specific areas, primarily seen in the districts of Damoh, Sehore, and parts of Raisen. The occurrence of normal erosion in these regions can be attributed to various environmental factors. Areas with loose or weathered rock formations are naturally prone to gradual physical disintegration, resulting in normal erosion processes. Anthropogenic or industrial erosion, marked in purple, is relatively sparse but noticeable in areas near urban and industrial centers, particularly around Sehore and parts of Hoshangabad. The factors

contributing to this type of erosion are primarily related to human activities. Urban expansion and infrastructure development disturb the natural soil and vegetation cover, increasing the likelihood of erosion. Mining activities, including quarrying and excavation, disrupt the landscape, causing localized degradation.

Regional differences are also apparent when examining the pattern of erosion across the Upper Narmada Basin. The eastern districts, including Mandla, Dindori, and Balaghat, shows extensive sheet erosion, likely due to their forested yet undulating terrain, where soil erosion is more pronounced during the rainy season. In contrast, the western parts, such as Sehore and Raisen, show a combination of erosion types, indicating the influence of both natural and anthropogenic factors.

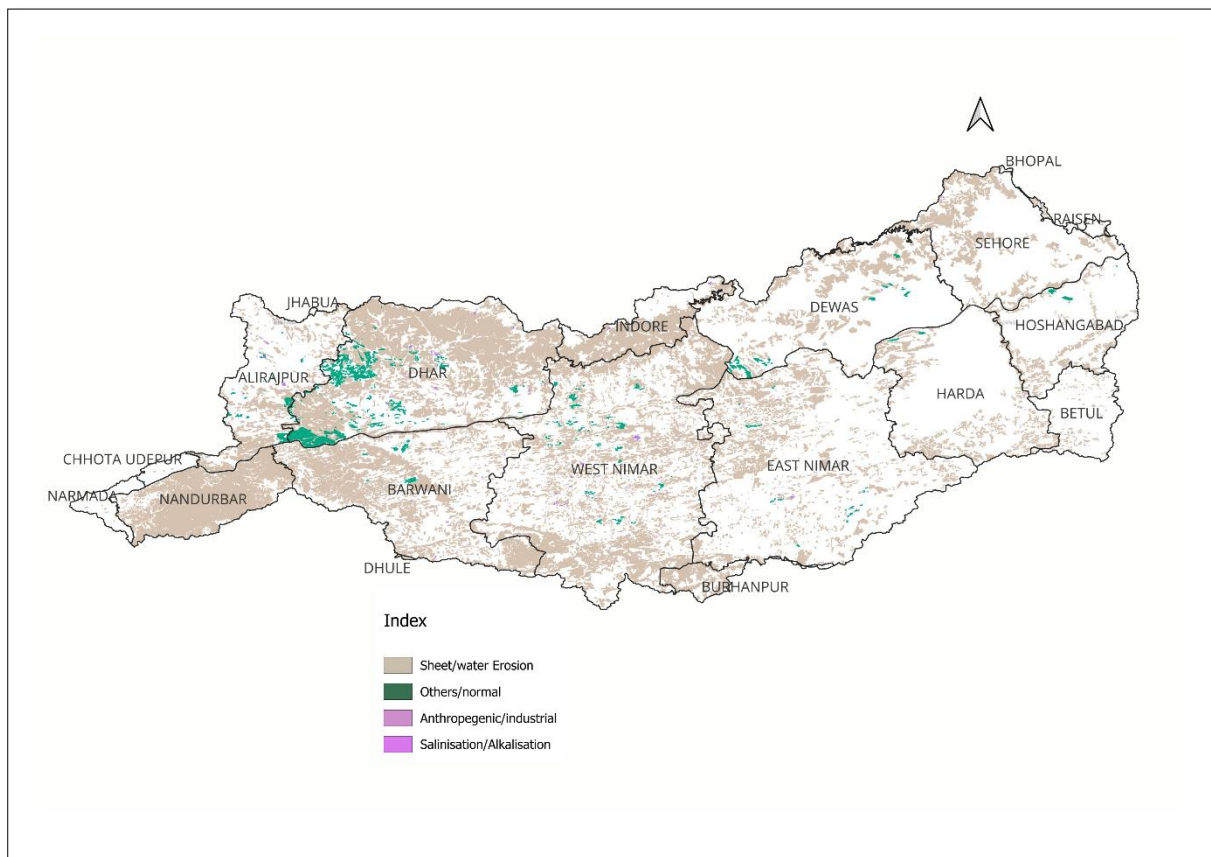


**Figure 9. Upper Basin: Land Degradation**

Source: Bhuvan, ISRO

## 7.2. Middle Narmada Basin

In case of Middle Narmada Basin, sheet erosion is prominently observed in the districts of Indore, Dhar, West Nimar, East Nimar, Harda, Hoshangabad and Nandurbar. The extensive occurrence of sheet erosion in these areas is likely due to the region's topography and agricultural practices without adequate soil conservation measures, particularly in areas with sloping land, also contribute to this degradation, particularly during heavy monsoon rains.



**Figure 10. Middle Narmada Basin: Land Degradation**

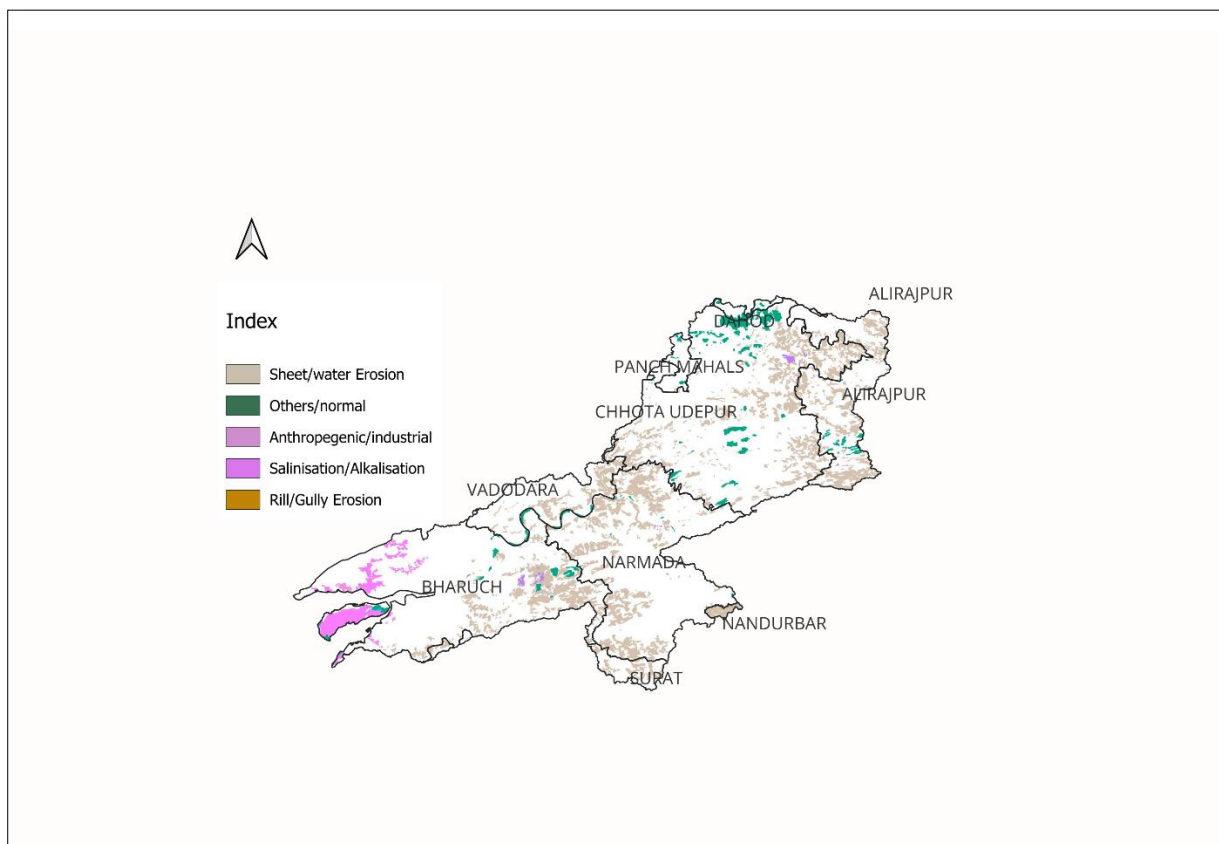
Source: Bhuvan, ISRO

Normal erosion occurs in limited areas but is notably present in districts like Dhar, Alirajpur, and Dewas. On the other hand, anthropogenic or industrial erosion, marked in purple, is relatively limited but evident near urban and industrial centers, particularly around Indore, Dewas, and parts of West Nimar. Rapid urbanization and industrial development in these regions have led to localized soil disturbance. Activities such as construction, mining, and

waste dumping compromise soil stability. A distinct pattern emerges when comparing different parts of the Middle Narmada Basin. The western districts, including Dhar and Alirajpur, show a combination of natural erosion processes like sheet erosion and normal erosion. In contrast, the central and eastern regions, particularly Indore and Dewas, exhibit a more pronounced influence of human activities leading to erosion.

### 7.3. Lower Narmada Basin

The Lower Narmada Basin presents various forms of land degradation, prominently including sheet/water erosion, other/normal, anthropogenic/industrial, salinization/alkalization, and rill/gully erosion (Figure 11). Sheet/water erosion is the most widespread form of degradation, covering large parts of districts such as Vadodara, Bharuch, Narmada, and parts of Surat and Alirajpur. On the other hand, normal erosion is observed particularly in the eastern and northern parts of the basin, including areas of Chhota Udepur and Panchmahal.



**Figure 11. Lower Narmada Basin: Land Degradation**

*Source: Bhuvan, ISRO*

Anthropogenic and industrial degradation is evident in the Bharuch district, where the presence of industrial zones and urban expansion contribute to land deterioration. The combination of chemical pollutants, waste disposal practices, and infrastructure development plays a significant role in this form of degradation. Since, Lower Narmada Basin is riparian of Arabian sea, salinization and alkalization are notably prominent in the coastal regions of Bharuch district, where the intrusion of saline water from the Arabian Sea have led to increased soil salinity and alkalinity, rendering land less productive for agriculture. Rill and gully erosion are less prevalent but are observed in the western parts of Bharuch, northern part of Narmada District and southeastern part of Vadodara district where concentrated runoff creates small channels that progressively deepen, contributing to soil loss and landscape instability.

## **8. Challenges in Revenue Mapping**

Working on the revenue mapping report for the Narmada Basin has posed several challenges, primarily due to the unavailability of basin-specific land records. One of the fundamental issues is the lack of comprehensive basin-wise land records, which forces reliance on satellite that is while particularly for land-cover classification (e.g., forests, agriculture, built-up areas), fails to provide actual revenue values tied to these categories. This limitation affects the accuracy of revenue assessment, as the data obtained does not directly translate into financial values.

Another significant challenge is the need for detailed revenue maps at the village or block level for a comprehensive basin study. Although village-level land records are accessible on state land-records websites, the process of acquiring these maps is overwhelming. Since the data is organized village by village, downloading maps individually becomes an difficult and

time-consuming task, especially when dealing with thousands of villages within a basin. This issue hinders the efficient collection and integration of data required for revenue analysis.

Data granularity issues also create challenges as data on revenue generation from different land categories specific to the basin or sub-basin level is unavailable. This data gap makes it difficult to assess how various land uses within the basin contribute to overall revenue. As a result, there is a reliance on broader district-level data, which may not accurately reflect the economic landscape of the basin, especially when only a small portion of a district falls within the basin boundary. It becomes more challenging when temporal inconsistencies arise i.e. using multi-year datasets, as data across states is not available for the same year.

The lack of basin-specific agricultural data, such as sown area, cultivated area, net sown area, and fallow land, further complicates revenue mapping. In most cases, data is available only at the district level, which fails to capture the specific agricultural dynamics within the basin. Consequently issue of generalisation of district-level data to the basin context occur, leading to potential inaccuracies in evaluating land use patterns and their associated revenue.

Addressing these challenges requires a multi-pronged approach, including integrating satellite data with ground truthing, developing basin-specific land use and land-revenue databases, and advocating for uniform data collection practices across states. Collaboration with local administrative bodies and the use of geospatial technologies can also enhance the accuracy and efficiency of revenue mapping in the Narmada Basin.

## **9. Conclusion and Recommendations**

The Revenue Mapping Report of the Narmada River Basin provides a comprehensive analysis of land-use categories, their distribution across sub-basins, and their socio-economic implications. The Narmada Basin, spanning Madhya Pradesh, Gujarat, Maharashtra, and Chhattisgarh, is a critical lifeline for central India, supporting agriculture, industry, and urban

settlements. The report categorizes land into forests, agricultural land, water bodies, built-up areas, and barren land, offering insights into resource management, ecological health, and revenue potential.

### **9.1. Summary and Key Findings**

The Upper Narmada Basin is characterized by dense forests, covering 24.76% of its area, with Mandla district having the highest forest cover (256,641 hectares). This region also has significant agricultural land (50.9%), though its hilly terrain limits cultivation compared to other sub-basins. Water bodies are concentrated in districts like Mandla and Hoshangabad due to reservoirs like Bargi Dam and Tawa. However, urbanization in Jabalpur and other towns has led to increased built-up land (2.996%), raising concerns about land-use conflicts. The Land-to-People Ratio (LtPR) reveals disparities, with Mandla having abundant forest resources (0.562 ha/person) while Jabalpur faces severe pressure (0.032 ha/person). Sheet erosion is widespread in this sub-basin, particularly in Chhindwara and Seoni, due to monsoon rains and undulating terrain.

The Middle Narmada Basin is the agricultural hub, with 63.75% of its land under cultivation, dominated by districts like West Nimar (571,233 hectares) and East Nimar (411,070 hectares). The Indira Sagar Reservoir contributes to extensive water bodies (148,504 hectares), supporting irrigation and hydropower. Forests are fragmented, with Dewas (35,409 hectares) and Betul (21,358 hectares) retaining significant cover. Urbanization is evident in Indore and Bhopal, though data gaps exist for built-up areas. The LtPR highlights Harda's high cropping intensity (0.570 ha/person), while tribal districts like Jhabua struggle with low ratios. Sheet erosion is prevalent in Indore and Dhar, exacerbated by unsustainable farming practices.

The Lower Narmada Basin, primarily in Gujarat, has the highest proportion of agricultural land (65.14%), with Bharuch and Narmada districts leading in productivity. Water bodies are concentrated near the Sardar Sarovar Dam (5,898 hectares), but coastal areas face salinization, degrading fertile land. Forests are limited (4.39%), with Narmada district (14,590 hectares) being an exception. Urban and industrial expansion in Vadodara and Surat has reduced cultivable land, reflected in their low LtPR (0.003 ha/person for forests in Vadodara). The region also faces rill/gully erosion and anthropogenic degradation, particularly in Bharuch's industrial zones.

The report underscores the need for balanced development, emphasizing conservation in forested areas, sustainable agriculture in productive zones, and mitigation of land degradation. It also highlights data gaps, particularly in basin-specific revenue records and temporal inconsistencies, which hinder accurate planning. The findings call for integrated management strategies to address ecological and economic challenges across the Narmada Basin.

## **9.2. Policy Recommendations and Suggestions**

Based on the findings, the report suggests:

- i. **Forest Conservation:** Enhance through community-led initiatives like Joint Forest Management (JFM) committees, reforestation with native species, and strengthened protected area management (e.g., Shoolpaneshwar Wildlife Sanctuary). Fire management strategies are also crucial to prevent forest fires.
- ii. **Sustainable Agriculture:** Promote precision irrigation (e.g., drip systems) with subsidies, soil health management via organic fertilizers, crop diversification with drought-resistant varieties, and agroforestry for biodiversity and income.



- iii. Land Reclamation: Implement erosion control measures like contour plowing and terracing, rehabilitate degraded lands (e.g., salinized areas with drainage systems), and monitor effectiveness through regular surveys.
- iv. Urban Planning: Develop sustainable urban plans with green spaces and efficient waste management, ensure water management through rainwater harvesting, and upgrade wastewater treatment to meet environmental standards.
- v. Data Management: Establish an integrated GIS platform for centralized data, conduct annual ground surveys for validation, and build capacity through training on GIS for stakeholders.

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