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Land Resource Inventory for 14 Selected Watersheds of Maharashtra for Land Use Planning Using Geo-spatial Techniques (PMKSY 2.0)

(WDC-2.0)6/2021-22: Dahanu, Dist - Palghar

ICAR-National Bureau of Soil Survey and Land Use Planning
Nagpur, Maharashtra

Vasundhara Watershed Development Agency
Pune, Maharashtra

About the ICAR-NBSS&LUP

The ICAR-National Bureau of Soil Survey and Land Use Planning (ICAR-NBSS&LUP), Nagpur was set up in the year 1976 with the objective to prepare soil resource maps at the national, regional, state and district levels, to provide research inputs for land evaluation, land use planning, land resource management and database management using GIS, and to impart training on soil survey and land use planning. The Bureau has the mandate to correlate and classify soils of the country and maintain a National Register of all the established soil series.

During the past decades, ICAR-NBSS&LUP provided the country with the first comprehensive soil resource maps of India and her states on 1:1 million and 1:250000 scales, respectively. The Bureau generated land resource inventories (LRIs) on different scales (1: 50,000 or larger) at watershed, block and district levels to aid planning agencies in the formulation and implementation of agricultural land use plans. Other landmark data products generated by the Bureau include the land degradation map of India, potential soil loss maps of different states, and agro-ecological region and sub-region maps of the country. The Institute has received commendable mention by the NITI Aayog for providing land use plans in respect of 27 Aspirational districts of India. Taking cognizance of the demands of various agencies to develop regional land use plans in the shortest possible time, the Bureau has recently developed a revised standard operating protocol (SOP) by combining traditional knowledge with GIS and machine learning tools. The revamped SOP was successfully adopted for bringing out the Land Resource Inventory of Bundelkhand, Vidarbha, Bikaner, Kachchh and South Gujarat regions of India. The Bureau has also released the first soil depth map and the National Soil Spectral Library of the country and is in the process of bringing out the digital soil map of Maharashtra state. ICAR-NBSS&LUP has also assisted several state governments in watershed planning through LRI under the PMKSY 2.0.

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PREFACE

Watershed development requires the systematic and integrated planning of social and technological interventions based on its socio-economic and bio-physical characteristics. Activities related to conservation/management of natural resources, enhancement of systems' productivity, livelihood support through micro-enterprises and businesses, are all planned in a holistic manner for ensuring sustainable gains from the watershed programme. Implementation of watershed plans follows the preparation of detailed project report (DPR), which in turn is based on comprehensive information obtained through on- and off-field surveys. While the data requirement for DPR preparation is substantial, adoption of a minimum data set covering major aspects of the watershed through use of advanced RS, GIS and machine learning tools could significantly reduce time taken for the same, while making it more pragmatic and user-friendly.

Comprehensive land use planning of any area begins with large-scale land resource inventory, which provides valuable data for crop and nutrient management planning, and supports scientific decision-making. Generation of Land Resource Inventory (LRI) by the ICAR-NBSS&LUP during the last two decades has been a proven critical input for planned agricultural development. Encouraged by the success of LRI based watershed programmes in Karnataka, many states have started using soil/land data for rural development. It is essential that LRI based development is extended to other parts of India through spreading awareness of its benefits. Administrators at national and state level(s) have recognized it and instructed that at least 10% area of the watersheds be covered under LRI in the plateau and upland region under the section 19.1.2 (b) of WDC-PMKSY 2.0 guidelines.

Being a frontrunner on several aspects of agricultural development, the Government of Maharashtra, through the Vasundhara Watershed Development Agency (VWDA), proactively entrusted the Bureau with the generation of LRI for 14 selected watersheds across different agro-ecological sub regions of Maharashtra for formulation of scientific land use plans using geo-spatial techniques. This report presents a comprehensive understanding of soils of the watershed in terms of their physical and chemical characteristics, nutrient status, crop suitability and soil and water conservation requirements. It is expected that this report will serve as a valuable resource for land users, watershed planners, researchers and policy developers in rationalizing land use and for implementing ongoing agricultural development schemes.

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The publication titled "Land resource inventory for 14 selected watersheds of Maharashtra for land use planning using geo-spatial techniques (PMKSY 2.0). (WDC-2.0)6/2021-22: Dahanu, Dist – Palghar" is the result of the collaborative efforts of the officials from the ICAR-National Bureau of Soil Survey and Land Use Planning (ICAR-NBSS&LUP), Nagpur and the Vasundhara Watershed Development Agency (VWDA), Pune, Maharashtra.

We are grateful to the Deputy Director General (NRM), Indian Council of Agricultural Research for his continuous support and guidance in successful completion of this project. We also sincerely thank the Assistant Director General (S&WM), NRM Division for his timely efforts and encouragement while implementing the project.

We place on record our deep sense of gratitude to the Chief Executive Officer(s), Deputy Chief Executive Officer(s), technical and administrative staff of the VWDA for entrusting us with this important project and for their financial and logistic support from the beginning to the completion of the project.

The authors express their sincere gratitude to all the scientists and technical staff, the I/c PME Cell, I/c Library, Chief Administrative Officer, Chief Finance and Accounts Officer, Administrative Officer, Assistant Administrative Officers and all other administration, accounts and audit sections of ICAR-NBSS&LUP, Nagpur, who ensured that the project continued smoothly. Their valuable help and cooperation in all respects are gratefully acknowledged.

Finally, we heartfully thank to all the project staff involved in the PMKSY 2.0-Maharashtra project for their untiring and steadfast efforts in the successful implementation of the project through data collection, analysis and documentation of the report.

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Executive Summary

The Pradhan Mantri Krishi Sinchayee Yojana - Watershed Development Component (PMKSY-WDC 2.0) emphasizes a scientific and participatory approach to watershed development through systematic assessment and management of land and water resources. In this context, Land Resource Inventory (LRI) provides a critical technical input for informed planning, prioritization of interventions, and sustainable management of natural resources. The ICAR-National Bureau of Soil Survey and Land Use Planning (ICAR-NBSS&LUP) was entrusted with the responsibility of conducting the LRI and offering technical assistance in the formulation of a holistic watershed development plan in accordance with the PMKSY-WDC 2.0 guidelines. ICAR-NBSS&LUP conducted the assessment for the Dahanu (WDC-2.0)3/2021-22 watershed located within the Dahanu Taluka of Palghar District, Maharashtra, underlain with the characteristic basaltic terrain of the Deccan Traps of the Deccan Plateau, with the Varoli river traversing the area. Agriculture constitutes the dominant land use within this watershed, primarily dependent upon monsoon precipitation, augmented by groundwater resources and various soil conservation structures.

The primary objectives of the study were to systematically characterize soil and land resources at watershed level, assess land capability and crop-site suitability, support watershed-based land use planning, and evaluate groundwater potential to aid sustainable watershed development under PMKSY-WDC 2.0.The assessment was conducted using the standard methodologies prescribed by ICAR-NBSS&LUP, involving pre-field analysis, detailed soil survey, laboratory characterization of soil samples, and GIS-based spatial analysis. Base maps and landform maps were prepared using authenticated datasets. Soil characteristics were recorded through field observations and laboratory analysis and subsequently classified following established soil classification systems. The watershed exhibits variability in landforms, slope, soils, and land use, which governs runoff generation, soil erosion, moisture availability, and groundwater occurrence. Soils show variations in depth, texture, drainage, and fertility status, reflecting differences in terrain position and land management practices. Hydrological assessment and groundwater potential evaluation were carried out using integrated thematic analysis to support identification of suitable areas for soil and water conservation and groundwater recharge interventions. The outcomes of the Land Resource Inventory provide a scientific basis for watershed-level land use planning, identification of resource constraints, and prioritization of soil and water conservation measures. The technical inputs generated by ICAR-NBSS&LUP are intended to support implementing agencies in designing location-specific interventions and promoting sustainable management of land and water resources under PMKSY-WDC 2.0.In conclusion, the Land Resource Inventory and watershed assessment carried out by ICAR-NBSS&LUP for the Dahanu sub-watershed constitutes an provide a comprehensive technical framework for scientific watershed planning and sustainable resource management, in accordance with the objectives and guidelines of PMKSY-WDC 2.0.

CHAPTER 1

INTRODUCTION

A region, block, district, or village's Land Resource Inventory (LRI) has proven to be an essential component of planned agricultural development. This inventory provides critical baseline data for effective watershed management and sustainable land use planning, particularly through the application of advanced geospatial technologies. Encouraged by the success of LRI-based watershed programs in Karnataka, many states have started using soil/land data for rural development.

Administrators at the national and state level(s) have recognized the significance of LRI and documented in the PMKSY 2.0 document that at least 10% area of the watersheds be covered under LRI in the plateau and upland region of the country. In addition to LRI, the agro-ecological zone approach is deemed to be most effective for regeneration of *in-situ* resources for sustaining the biological growth and, in turn, soil health. Agro-ecological regions and subregions delineated by the ICAR-National Bureau of Soil Survey and Land Use Planning (ICAR-NBSS&LUP) therefore form the ideal base for selection and planning of watershed development, as our understanding of soil-crop and weather interactions is greatly enhanced under this approach.

The Government of Maharashtra directed the Bureau to conduct a Land Resource Inventory (LRI) in 14 watersheds located in different agro-ecological zones of the state. The objective is to measure improvements and ensure the long-term health of farming and related activities in rainfed areas, which will benefit the local farmers.

The process for selecting these watersheds was designed to fairly represent where existing projects were located across Maharashtra's distinct regions. As a result, four watersheds were selected for both the Vidarbha and Konkan regions, as they had a high number of ongoing projects. Western Maharashtra, Marathwada, and Northern Maharashtra were each assigned two watersheds, reflecting a lower concentration of implemented projects.

The project, planned for 48626 ha was implemented with the following objectives:

1. To characterize and map the soil and water resources of the watersheds.
2. To assess the soil-site suitability of the crops based on land evaluation at the watershed level.
3. To develop watershed-based alternate land use options and soil and water conservation plans.
4. To assess and characterize the groundwater potential of the watersheds.

This report presents the Land Resource Inventory (LRI) conducted in the Dahanu (WDC-2.0/4/2021-22) sub-watershed of Dahanu Taluka under the Pradhan Mantri Krishi Sinchayee Yojana - Watershed Development Component (PMKSY-WDC 2.0). The study involved detailed field visits, soil observations, mapping, and assessment of local hydrological conditions. The information collected was carefully analyzed to understand land capability, soil suitability, drainage patterns and groundwater potential. These findings provide a practical foundation for planning watershed development and soil and water conservation measures suited to local conditions.

List of micro watersheds (MWS) earmarked for LRI studies by the ICAR-NBSS&LUP

District	Project name	Block	No. of MWS	No. of villages	Area (ha)
Akola	Akola (WDC-2.0)1/2021-22	Barshitakli	11	8	4898.0
Buldhana	Buldhana (WDC-2.0)3/2021-22	Lonar	21	4	2498.5
Nandurbar	Nandurbar (WDC-2.0/4/2021-22	Nandurbar	5	14	3533.2
Nashik	Nashik (WDC-2.0)3/2021-22	Malegaon	7	7	2760.4
Osmanabad	Osmanabad (WDC-2.0)3/2021-22	Tuljapur	25	10	3380.0
Palghar	Palghar (WDC-2.0) 6/2021-22	Dahanu	7	23	3926.2
Parbhani	Parbhani (WDC-2.0/3/2021-22	Gangakhed	8	9	3791.0
Raigad	Raigad (WDC-2.0)/2/2021-22	Roha	3	11	3825.0
Ratnagiri	Ratnagiri (WDC-2.0)/3/2021-22	Chiplun	13	9	2548.0
Sangli	Sangli (WDC-2.0)3/2021-22	Jath	23	5	3200.0
Sindhudurg	Sindhudurg (WDC-2.0)/3/2021-22	Dodamarga	5	5	3604.4
Solapur	Solapur (WDC-2.0)2/2021-22	Mangalwedha	31	7	4198.1
Wardha	Wardha (WDC-2.0)/3/2021-22	Seloo	12	7	2657.5
Washim	Washim (WDC-2.0)/5/2021 -22	Malegaon	21	8	3806.1
Total			**192**		**48626.9**

CHAPTER 2

DAHANU WATERSHED AT A GLANCE

2.1 Location and Extent

The watershed is situated in Dahanu Taluka which is one of the administrative subdivisions of Palghar District, located in the northern coastal region of Maharashtra. The study area lies between 19°53’ to 20°20’ N latitude and 72°39’ to 73°0’ E longitude. Watershed is predominantly rural, with agriculture forming the primary livelihood and forested patches interspersed across the landscape. The Varoli River, is the major river flowing through the study area, serving as the primary water source for irrigation, domestic use, and industrial activity.

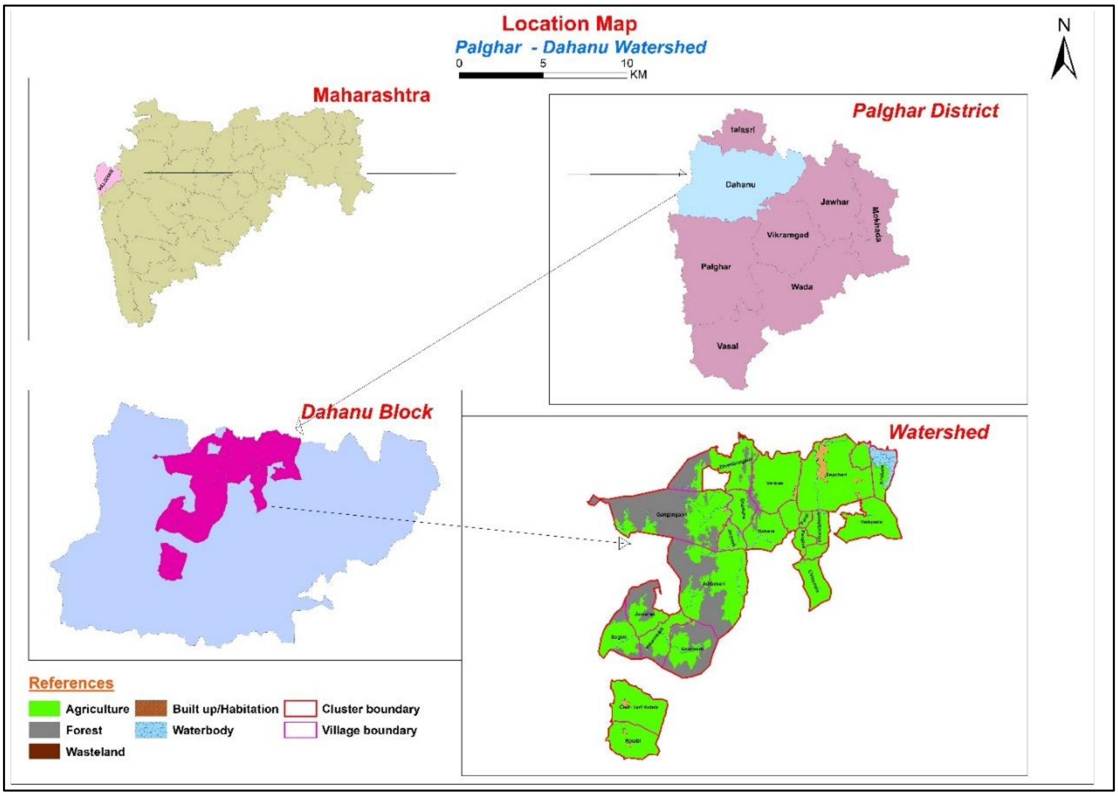


Fig. 2.1: Location map of the Dahanu watershed

Dahanu Taluka comprising dispersed villages which are largely rural with rainfed agriculture being the primary livelihood. The region is prone to high surface runoff during monsoons, leading to soil erosion, declining groundwater levels, and water scarcity during the post-monsoon months. This situation, which persists despite high annual rainfall, formed the rationale for selecting this area for watershed-based natural resource management interventions. Table 2.1 provides the general profile in respect of the watershed.

Table 2.1: Geographical and administrative profile

Sr. No.	Particulars	Details
	District	Palghar
	Taluka	Dahanu
	Revenue division	Konkan
	Total watershed area	Approx. 13,753 hectares
	Villages	22 villages (Ambesari, Bahare, Bramhanwadi, Chari Tarf Kotebi, Chinchale, Dapchari, Dhamanagaon, Dhundalwadi, Gangangaon, Gaurwadi, Ghadane, Halapada, Jamshet, Jingaon, Khubale, Pardi, Punjave, Sasvand, Sogwe, Vankas, Varkhande, and Vasantwadi)
	Major River	Varoli
	Average annual rainfall	2598 mm

2.2 Geology

Geologically the watershed is predominantly made up of Deccan Trap basalt, which forms the main geological foundation of the area. These basaltic lava flows, dating from the Upper Cretaceous to Eocene, are arranged in horizontal layers and show a mostly massive and amygdaloidal texture. This rock formation gives rise to the characteristic flat-topped hills and step-like terraces seen across the watershed. The consistent basaltic bedrock plays a key role in shaping soil development, controlling surface runoff, and influencing groundwater occurrence, while also providing a stable base for agriculture and other land uses.

2.3 Geomorphology

Geomorphologically, the Dahanu watershed is shaped largely by its basaltic foundation and exhibits a varied terrain ranging from 1 to 543 m above mean sea level. The landscape is dominated by gently sloping pediments, undulating hills and ridges, pediplains, and valleys, with foothills marking transitions between upland and lowland areas. Plateau tops and isolated mounds occur in smaller portions of the watershed. The Varoli River, along with its seasonal tributaries, defines the main drainage network, carving valleys and depositional zones that influence soil accumulation and surface runoff. This combination of erosional and depositional landforms provides opportunities for ridge-to-valley interventions to improve soil and water conservation, enhance groundwater recharge, and support agricultural activities across the watershed.

2.4 Physiography and Soil

The physiography of the study area comprises a diverse set of landform units that include foothills, hills and ridges, pediments, pediplains, plateau tops, valleys, isolated mounds, canal corridors, and reservoir zones. These landforms collectively create a landscape that varies from low-lying stretches to elevated structural features. The slope across the cluster ranges from 0% to 185% rise, showing the presence of nearly level surfaces in certain parts and extremely steep gradients in specific hill sections. This wide slope variation reflects the natural relief differences recorded in the mapped terrain. The soils in the cluster consist primarily of clay & silty clay loam, which forms the dominant category. Additional soil classes recorded in the mapped dataset include, clay loam, silty clay and loam, occurring in smaller or scattered patches. Each soil type is part of the identified soil distribution pattern within the area and represents the mapped variability observed in the dataset. These soils are well-drained but shallow to very deep profiles and have good moisture retention capacity, well-drained yet erosion-prone in higher altitudes. They support paddy cultivation in the lowlands and cashew, mango, or forest scrub in uplands.

2.5 Climate

The watershed in Dahanu taluka experiences a humid tropical monsoon climate (Köppen climate classification 'Am'), which is typical of the coastal Konkan region of Palghar district. The area receives heavy rainfall during the southwest monsoon due to its location on the windward side of the Western Ghats, resulting in humid climatic conditions throughout much of the year. The climate of the area is largely controlled by the southwest monsoon, which brings most of the rainfall between June and September. The average annual rainfall is about 2598 mm, indicating relatively high rainfall conditions compared to many other parts of Maharashtra. A major portion of the annual rainfall is received during the monsoon months, while the remaining part of the year remains comparatively dry. Temperature variation is relatively small due to maritime influence; May is generally the hottest month, while January is the coolest. Relative humidity remains high throughout the year, varying roughly between 40% and 100%, with maximum humidity during the monsoon season. Skies remain heavily clouded during the monsoon months, while the rest of the year experiences clear to partly cloudy conditions. Winds predominantly blow from the west and northwest with moderate speed, increasing during the monsoon period.

2.6 Drainage

The drainage system of the watershed is primarily controlled by the Varoli River, which serves as the main channel collecting runoff from the surrounding hills, pediments, and valleys. The river is fed by numerous seasonal streams and natural nalas that flow predominantly during the southwest monsoon. These tributaries carry surface runoff from the upland basaltic and pediplain areas into the main river, creating a dendritic drainage pattern typical of basaltic terrains. The gentle slopes of pediments and pediplains facilitate moderate surface flow, while valleys and foothill zones act as natural collection and deposition areas. Overall, the drainage network plays a key role in channelling monsoonal runoff, supporting groundwater recharge, and influencing land-use potential across the watershed.

2.7 Cropping Patterns, and Demography and Socioeconomics

2.7.1 Cropping Pattern

The agricultural landscape of the Dahanu cluster is predominantly rainfed and largely dependent on the southwest monsoon. Paddy is the principal kharif crop cultivated in low-lying fields, while finger millet (nagli) is grown in upland areas. Limited cultivation of pulses and vegetables is practiced during the rabi season using residual soil moisture. The region is well known for its horticultural crops, particularly the GI-tagged Gholvad chikoo (sapota), which forms the commercial backbone of the local economy. Mango, coconut, and other fruit crops are also cultivated in orchards, contributing significantly to the agricultural livelihood of farmers in Dahanu Taluka.

2.7.2 Demographic and Socioeconomic Status

Palghar District is characterized by a contrast between its rapidly urbanizing centers and its deeply rooted indigenous rural areas. The district has a significant Scheduled Tribe (ST) population, which is also reflected in the study cluster where tribal communities constitute a major proportion of the population. The region maintains a rich linguistic and cultural diversity, with languages such as Marathi, Varli, and Gujarati widely spoken. Traditional communities such as the Warli tribe and Koli community play an important role in the socio-economic fabric of the area, sustaining livelihoods primarily through agriculture, fishing, and allied activities.

2.8 Water Resources

2.8.1 Surface Water

Dahanu Taluka’s surface water resources consist of seasonal streams and small nalas that flow primarily during the monsoon and largely dry up afterward. The region has a few irrigation dams and reservoirs. A notable structure in the Dahanu area is Kurje Dam (also called Dhapcheri Dam), an earth-fill dam on a local river, providing water supply and limited irrigation capacity. There is canal network, and surface water use is largely limited to small reservoirs, percolation tanks, check dams, and farm ponds, including Kurje Dam, many of which have reduced storage capacity or are partially silted.

2.8.2 Groundwater

Groundwater occurs mostly in weathered and fractured zones of basalt rock. According to the Dynamic Ground Water Resources of Palghar District (CGWB), 2024, annual extractable ground water resources place the region under the “safe” category, with the groundwater extraction level under 31.5%

2.8.3 Irrigation and Water Management

Water management in the region focuses on balancing heavy monsoon runoff with acute summer scarcity. While traditional methods like *Rahats* and *Bhands* were historically vital, modern agriculture increasingly relies on a mix of open wells and micro-irrigation systems. To combat coastal soil salinity and groundwater depletion, the district employs integrated watershed techniques such as check dam rejuvenation, farm ponds, and Broad Bed Furrow (BBF) systems for in-situ moisture conservation.

2.9 Constraints

The following key issues were observed in the cluster villages, both through field surveys (2024-25) and community consultations:

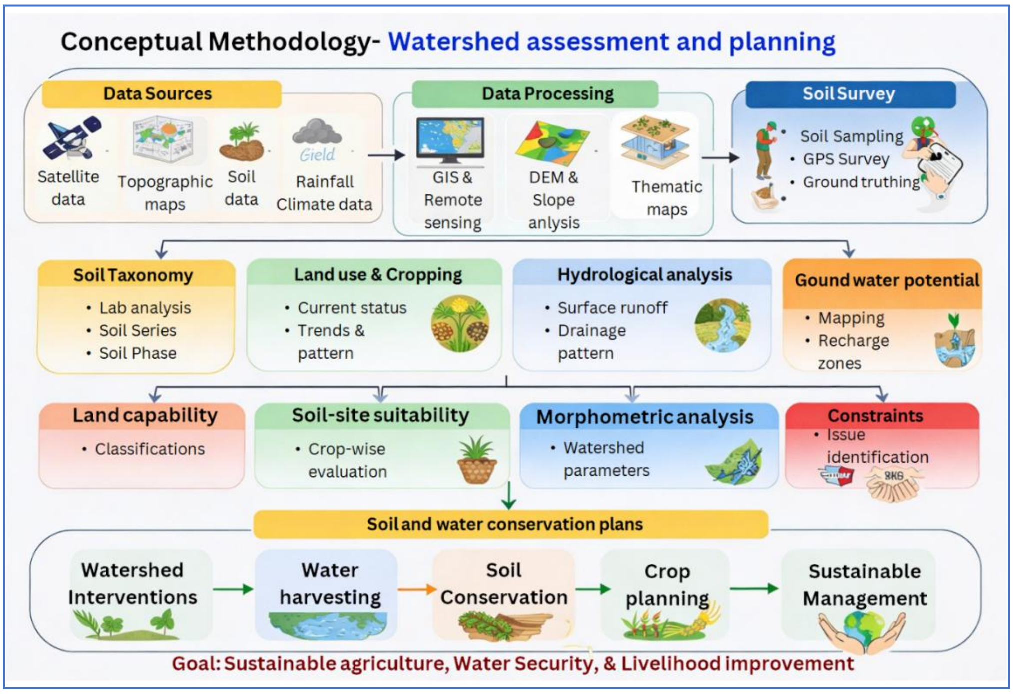
a. High runoff losses: Despite receiving over 2598 mm of rainfall annually, some of it is lost as surface runoff due to lack of water-harvesting structures and steep terrain.
b. Soil erosion in upland areas, especially on exposed slopes.
c. Limited irrigation coverage.
d. Groundwater levels show seasonal fluctuations.
e. Existing water harvesting structures are partially silted or have reduced storage capacity.
f. Village ponds and embankments are used for limited water storage but often do not meet full domestic and agricultural needs.

CHAPTER 3

METHODOLOGY

3.1 Overview of activities

The following figure depicts the overall flow of activities adopted for the project:



The various activities involved in the generation of land resource data and maps can be broadly grouped under pre-field, soil survey, post-field and post-LRI activities, as listed below:

A. Pre-field

- Procurement of high-resolution satellite imageries, cadastral maps, geology/physical maps
- Image interpretation for physiography/landforms/land use
- Finalization of physiography/landform map with legend as base maps.

B. Soil survey

- Selection of transects (cutting across as many physiographic units as possible)
- Digging of soil profile pits up to 1.5 m depth or hard rock, whichever is earlier
- Examination and description of soil profiles in transects
- Study and record of soil-site characteristics
- Collection of soil samples from the pedons of each soil series
- Field review (preliminary, progressive and final) for soil correlation
- Grouping of soil profiles studied at each transect into soil series
- Development of progressive soil legend
- Mapping of soil phases (management units)

- Mapping of current land use/land cover, existing soil and water conservation structures etc.

C. Post-field phase

- Processing of soil samples, and laboratory analysis for physical, physico-chemical properties
- Compilation and interpretation of data
- Generation of thematic maps (slope, erosion, soil depth, drainage, pH, SOC, N, P, K and micronutrients, etc.)
- Land evaluation for various suitability classes for different crops and irrigation
- Preparation of soil and water conservation maps
- Developing soil mapping unit wise alternate land use options
- LRI report write-up

3.2 Preparation of Base Maps

Spatial data preparation began by georeferencing Survey of India (SOI) toposheets at a 1:50,000 scale, utilizing the WGS 84 datum and UTM projection supported by field - verified Ground Control Points (GCPs). Landform delineation was executed within a GIS environment, integrating 30 m resolution SRTM Digital Elevation Models (DEM) with systematic on-screen visual interpretation. This geomorphic analysis relied on fundamental image elements - including shape, tone, colour, pattern, shadow and texture - to identify land features. To enhance interpretation, False Colour Composites (FCC) were generated through various satellite band combinations. Final mapping of land use/land cover (LULC) and landform units was conducted using ArcGIS software.

3.3 Ground-truth Verification

The area was traversed to identify different landform units, slope and present land use/land-cover (LULC) classes, and correlated with image interpretation units. The boundaries that were originally derived during the base map preparation were verified and corrected wherever necessary. To understand the soil variability in the study area, representative sites on each landform unit were selected, located using handheld Global Positioning System (GPS) and 30 profiles observations were taken and studied for morphological properties in the field following the guidelines for field soil descriptions (Soil Survey Division Staff 2000) and were recorded in the standard format.

3.4 Soil Sampling and Analysis

Soil samples from each horizon of all of the representative soil series were collected for laboratory studies. The soil samples collected during the fieldwork were initially air dried in the laboratory at room temperature, ground using a wooden pestle and mortar, screened through a 2 mm sieve, properly labelled, and stored in polythene bags for laboratory analysis. The soil samples were analysed in the laboratory for physical and chemical parameters using standard procedures. The particle size analysis was done by international pipette method. A combined glass-calomel electrode was used to determine the pH measured (1:2.5 soil/solution ratio). Soil organic carbon (SOC) was determined using the wet digestion method of Walkley and Black (1934). Available nitrogen (N) was measured by the alkaline permanganate method as described by Subbiah and Asija (1956). Available phosphorus (P) was determined by the Bray II method (Bray and Kurtz 1945). Cation exchange capacity (CEC) of soil was measured as per the procedure outlined by Jackson (1976). Exchangeable cations [calcium (Ca), potassium (K), and magnesium (Mg)] were extracted with 1 M ammonium acetate (NH4Oac) (pH 7.0). Potassium content was determined by flame photometry (Rich 1965), while Ca and Mg were determined in ethylene diamine tetra acetic acid (EDTA) titration. Exchangeable Al was extracted with 1 N potassium chloride (KCl) solution and titrated with 0.1 N sodium hydroxide (NaOH) solution. Available micronutrient content [copper (Cu), manganese (Mn), iron (Fe), and zinc (Zn)] was determined by diethylene triamine penta-acetic acid (DTPA) extraction (Lindsay and Norvell 1978), followed by atomic absorption spectrophotometry. Soils were classified according to Keys to Soil Taxonomy (Soil Survey Staff 2010).

3.5 Development of Soil Mapping Legend

In the present study, soil series phases were used as the basic mapping units. A soil series refers to a group of soils or polypedons that exhibit similar horizon sequences and share closely related properties within a narrow range of variation (Soil Survey Division Staff, 2000). The phases considered in this study included soil depth, surface texture, slope, erosion status and flooding conditions. Soil profiles were examined and correlated within each major landform and soil series were identified accordingly. The identified soil series information was then extended to the sub-units of major landforms based on diagnostic soil characteristics observed from soil profile descriptions and auger observations. A detailed soil map depicting soil series and their respective phases was prepared at a scale of 1:10,000. The soil legend code developed for the map represents the soil series name followed by surface texture, slope class, erosion status and soil depth, as described by Singh et al. (2016).

3.6 Surface Runoff Estimation

Direct surface runoff occurring in the Dahanu watershed was estimated using the Soil Conservation Service Curve Number (SCS-CN) method, employing daily rainfall data from 2014 to 2024. The SCS-CN method is widely used for estimating surface runoff as it establishes a functional relationship between rainfall, land use, soil conditions, and the physical characteristics of the landscape. The method is based on the Curve Number (CN), a dimensionless parameter that reflects the runoff potential of an area depending on land use, soil type, and hydrologic condition. The CN plays a decisive role in determining the proportion of rainfall that contributes to direct runoff. The watershed area was delineated into individual spatial polygons representing homogeneous units of land use, soil, and slope characteristics to capture spatial variability across the landscape. For each polygon, the appropriate Hydrologic Soil Group (HSG) was assigned based on soil infiltration capacity and other physical characteristics. The CN for each polygon was determined according to its corresponding land use and soil group combination. This polygon-based approach enabled a more spatially refined estimation of runoff, as runoff potential varies across different parts of the watershed.

The Antecedent Moisture Condition (AMC), a measure of soil moisture based on the previous rainfall events, was computed daily. The AMC plays an important role in adjusting the CN because soils that are already saturated are more likely to produce runoff than those that are dry. The AMC was computed using the rainfall data from the previous five days, and based on the resulting moisture condition, the CN for the day was adjusted accordingly. This adjustment helps account for variations in runoff potential that result from antecedent moisture conditions. After calculating the CN for each unit, the weighted average CN for the entire study area was computed, considering the area of each polygon. The initial abstraction (S), which represents the portion of rainfall that does not contribute to runoff (e.g., water that is stored in depressions, infiltrates into the soil, or evaporates), was also estimated using CN values. The runoff for each month and year was then calculated, with data from 2014 to 2024 providing insights into seasonal and yearly runoff patterns within the watershed.

3.7 Groundwater Potential Zone Mapping

The groundwater potential of the watershed was determined using a comprehensive approach that integrates eight thematic layers to provide valuable insights for the sustainable management of this critical resource. Each of the thematic layer represents a factor influencing groundwater availability, and include soil, slope, drainage density, elevation, land use/land cover (LULC), rainfall, geomorphological landform units, and lithology. A multi-criteria decision-making (MCDM) approach was adopted to integrate these layers for assessing the groundwater potential across the region. Each thematic layer contributes uniquely to the understanding of groundwater potential. For instance, the type and permeability of soil play a vital role in groundwater recharge and storage capacity. The slope of the land influences the infiltration rate and surface runoff, with steeper slopes typically having lower groundwater recharge potential. Drainage density, which refers to the network of streams or rivers in the area, affects groundwater recharge by facilitating water flow into the ground. Elevation is another important factor, as it dictates the direction of water flow, with lower areas often being more favorable for groundwater accumulation. The land use/land cover type also has a direct impact, with urban areas typically having lower groundwater potential due to impervious surfaces, while agricultural and forested areas are generally more conducive to recharge. Rainfall is a key driver of groundwater replenishment, as it is the primary source of recharge, with the quantity, distribution, and seasonality of rainfall significantly influencing groundwater availability. The geomorphological landforms also play an essential role in shaping groundwater potential, as different landforms, such as valleys and plateaus, influence the movement and storage of groundwater. Lastly, lithology, or the geological composition of the region, determines the porosity and permeability of rocks, which in turn affects groundwater storage and movement.

The relative importance of each of these factors was assessed by employing the Analytical Hierarchy Process (AHP), a decision-making tool that allows the integration of expert opinions and subjective judgment in a structured manner. AHP assigns weights to each thematic layer based on its significance in influencing groundwater potential. Expert opinions, along with a thorough review of existing literature, guide the determination of these weights, ensuring that all relevant factors are carefully considered. The weight assigned to each layer reflects its relative contribution to groundwater availability in the watershed. This step is crucial for ensuring that the final groundwater potential map accurately reflects the different factors that affect groundwater in the region. Once the weights are assigned, the study applies the Weighted Sum Method (WSM) to integrate the normalized thematic layers into a composite groundwater potential index. The normalization process ensures that each thematic layer contributes appropriately to the overall assessment, regardless of its numerical scale. The WSM method allows for a systematic integration of the layers, combining them in a way that reflects their relative importance and generating a comprehensive map of groundwater potential zones in the Dahanu watershed. This composite groundwater potential index is then used to classify the region into five distinct categories: very poor, poor, moderate, good, and very good potential. These categories represent the varying levels of groundwater availability across the region, helping to identify areas where groundwater resources are abundant, as well as those where availability is limited.

3.8 Land Evaluation

The evaluation of soil-site suitability was carried out to understand how well the land resources of the watershed can support sustainable crop production under existing environmental conditions. The approach combines information on soil properties, terrain features, and climate to assess the capability of different land units to meet the growth requirements of various crops, thereby supporting scientific land-use planning.

The assessment was conducted using the maximum likelihood method based on the guidelines proposed by Sys et al. (1993) and Naidu et al. (2006). Detailed field surveys, laboratory analysis of soil samples, and interpretation of spatial datasets were used to generate a comprehensive soil and site database. Since the watershed area is relatively small, temperature and rainfall were considered uniform across the entire area and treated as constant climatic inputs for the suitability evaluation.

Soil wetness conditions, including drainage status and the possibility of flooding, were examined to understand soil aeration and moisture availability. Physical soil characteristics such as surface texture and effective soil depth were assessed to evaluate their influence on root growth, water retention, and nutrient uptake. Soil fertility indicators, including pH, soil organic carbon, apparent cation exchange capacity, base saturation, and exchangeable cations, were analyzed to determine the nutrient-supplying capacity of soils. In addition, terrain features such as slope and erosion risk were considered to understand their impact on runoff, soil loss, and field operations.

Each soil and site factor was rated according to its degree of limitation to crop growth, and the combined effect of these limitations was used to determine overall land suitability. Based on this integrated analysis, soils were grouped into five suitability classes: highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and not suitable (N). This classification helps in identifying suitable crops, planning appropriate management practices, and promoting sustainable agricultural development within the watershed.

3.9 Morphometric Analysis

Morphometric analysis was carried out to understand the drainage characteristics and hydrological behavior of the study area. A Digital Elevation Model (DEM) was used as the primary dataset to derive terrain and drainage information. The DEM was processed in a Geographic Information System (GIS) environment to remove sinks and generate flow direction and flow accumulation grids. Based on the flow accumulation threshold, the drainage network was extracted and stream orders were assigned using the Strahler stream ordering method.

Using the derived drainage network and flow direction layers, watershed and sub-watershed boundaries were delineated by identifying outlet points along the main drainage channels. The resulting hydrologically closed units were used as the basis for morphometric analysis. Linear, areal, and relief morphometric parameters were computed using standard equations widely adopted in geomorphological studies (e.g., Horton, 1945; Strahler, 1964; Schumm, 1956). Linear parameters such as number of streams, stream length, bifurcation ratio, channel length, and basin perimeter were calculated from the extracted stream network. Areal parameters including basin area, drainage density, stream frequency, form factor, elongation ratio, circularity ratio, compactness coefficient, and length of overland flow were derived to evaluate watershed shape, drainage efficiency, and runoff potential. Relief parameters such as basin relief, relief ratio, ruggedness number, and Melton ruggedness number were estimated using elevation data from the DEM to assess terrain characteristics and erosion susceptibility.

The morphometric analysis was conducted at the watershed and sub-watershed scale, as these parameters depend on natural drainage boundaries rather than administrative limits. The derived indices were subsequently interpreted to understand runoff generation, erosion susceptibility, and groundwater recharge potential within the watershed system. The results were further used to support soil and water conservation planning and watershed management strategies for the study area.

3.10 Identification of Soil and Water Conservation Measures

The identification and spatial allocation of soil and water conservation (SWC) measures within the village cluster watershed of Dahanu Taluka were carried out through an integrated geospatial and land resource assessment approach. A comprehensive spatial database was prepared using high-resolution satellite imagery, digital elevation models (DEM), soil resource maps, land use/land cover data, and drainage network information.

From the DEM, slope classes, flow accumulation, and drainage patterns were derived to understand runoff movement and erosion-prone areas within the watershed. Soil resource information, including soil depth, texture, and drainage characteristics, was integrated with land use data to assess land capability and constraints affecting agricultural productivity.

Based on these datasets, land capability assessment and terrain analysis were performed to delineate management units within the watershed. Each unit was evaluated for its suitability for specific conservation interventions by considering parameters such as soil depth, slope gradient, existing land use, runoff potential, and proximity to drainage lines. Decision rules commonly used in watershed planning were applied to assign appropriate measures. For example, field bunding and strengthening of existing bunds were recommended in cultivated lands with gentle slopes to reduce runoff and enhance in situ moisture conservation, while conservation bench terraces were proposed in unbunded agricultural areas with moderate slopes where soil depth permitted terracing. The Broad Bed and Furrow (BBF) system was identified for agricultural fields, particularly in medium to deep soils, to improve surface drainage and soil moisture distribution under rainfed conditions.

Water harvesting interventions were identified based on runoff contributing areas, drainage density, and storage potential. Farm ponds were proposed in agricultural fields with suitable catchment areas, while lined farm ponds were recommended in locations with higher seepage potential. Structural measures such as cement nala bunds (CNB) and earthen nala bunds (ENB) were proposed along drainage lines after evaluating channel characteristics, contributing catchment area, and groundwater recharge potential. Renovation and desilting of existing water bodies and farm ponds were suggested based on field observations and spatial identification of existing structures.

Vegetative interventions were planned in areas characterized by scrubland, degraded lands, or drainage margins, where afforestation and stream bank plantations could help stabilize soil and reduce erosion. Horticultural plantations supported with in situ moisture conservation practices were proposed in suitable land parcels to enhance land productivity. Additional measures such as rooftop rainwater harvesting in built-up areas and road-side drainage protection works were identified to capture and safely manage runoff from non-agricultural surfaces. Through the integration of terrain analysis, soil resource information, land use assessment, and hydrological considerations, site-specific conservation measures were systematically identified and spatially allocated within the watershed. This approach ensured that the proposed interventions are technically suitable, hydrologically effective, and aligned with the existing land resource conditions of the watershed.

CHAPTER 4

RESULTS AND INTERPRETATIONS

4.1 Irrigation, Cropping Patterns, and Demography and Socioeconomics

A field survey was conducted to document the availability of water resources, cropping patterns, and the demographic and socio-economic characteristics of farmers in the watershed. The results obtained from this survey are presented in the following sub-sections.

4.1.1 Irrigation and water management

The seasonal distribution of irrigation sources in the Dahanu watershed is presented in Table 4.1. During the Kharif season, borewells found to be the largest irrigation source, contributing to 40.76% of the total seasonal irrigation, followed by well irrigation (25.62%), farm ponds (20.07%), and canal irrigation (13.56%), indicating that groundwater sources play a significant role in supporting crop cultivation during the monsoon season. In the Rabi season, borewells contribute highest area of 43.68% of the seasonal irrigation. Wells contribute 25.89% of the total seasonal irrigation, while farm ponds contribute 19.68%. Canal irrigation contributes 10.74%.The irrigation pattern of the cluster shows a high dependence on groundwater sources such as borewells and wells, which together account for the majority of irrigation in both seasons. Surface water sources such as farm ponds and canals act as supplementary irrigation sources, helping farmers meet crop water requirements during critical growth stages.

Table 4.1 Seasonal distribution of irrigation sources in the Dahanu watershed

Sr. No.	Number of Farmers Interviewed (n)	Irrigation Source	Seasonal Water Availability	Contribution to Season's Total Irrigation (%)
1	138	Rainfed	Kharif	0.00
2	76	Borewell	Kharif	40.76
3	69	Borewell	Rabi	43.68
4	52	Well	Kharif	25.62
5	46	Well	Rabi	25.89
6	34	Farm Pond	Kharif	20.07
7	27	Farm Pond	Rabi	19.68
8	19	Canal	Kharif	13.56
9	15	Canal	Rabi	10.74

4.1.2 Cropping Pattern

The cropping pattern of the study area reflects a combination of seasonal field crops and perennial horticultural crops presented in Table 4.2. From the total farmers interviewed, the gross cropped area is 498.7 ha and the net sown area is 421.3 ha.

$$Cropping\ intensity(\%) = \frac{Gross\ cropped\ area}{Net\ sown\ area} \times 100$$

$$Cropping\ intensity(\%) = \frac{498.75}{421.3} \times 100 = 118.4\%$$

The cropping intensity of the Palghar watershed is 118.4%. In the Kharif season, Rice is the most dominant crop, occupying 38.6% of the total cropped area with a productivity of 2410 kg/ha, making it the principal staple crop of the region. Other Kharif crops include Jowar, which occupies 4.0% of the cropped area with a productivity of 980 kg/ha. A significant number of perennial horticultural crops also contribute to agricultural production. Mango occupies 11.7% of the cropped area with a productivity of 6120 kg/ha, followed by Cashew (10.0%, 1180 kg/ha) and Coconut (7.3%, 8420 kg/ha). Other important perennial crops include Arecanut (5.9%, 2980 kg/ha), Sapota (5.3%, 7120 kg/ha), Banana (4.6%, 31,400 kg/ha), Jackfruit (3.1%, 5360 kg/ha) and Oil palm (2.5%, 10,400 kg/ha). In the Rabi season, Chilli occupies 3.5% of the cropped area with a productivity of 2480 kg/ha, while Rabi rice covers 1.6% of the cropped area with a productivity of 2660 kg/ha. The cropping pattern of the cluster indicates dominance of Kharif Rice cultivation and perennial horticultural plantations, which contributes to crop diversification and improved farm productivity in the region.

Table 4.2 Crop-wise distribution in the Dahanu watershed

Sr. No.	Season	Crop	No. of Farmers Interviewed (n)	Irrigation Type	Total Cropped Area (%)	Productivity (kg/ha)
1	Kharif	Rice	164	Rainfed	38.62	2410
2	Perennial	Mango	72	Rainfed	11.71	6120
3	Perennial	Cashew	61	Rainfed	9.96	1180
4	Perennial	Coconut	44	Irrigated	7.32	8420
5	Perennial	Arecanut	39	Irrigated	5.85	2980
6	Perennial	Sapota	34	Irrigated	5.29	7120
7	Perennial	Banana	31	Irrigated	4.63	31400
8	Kharif	Jowar	28	Rainfed	3.95	980
9	Rabi	Chilli	26	Irrigated	3.49	2480
10	Perennial	Jackfruit	21	Rainfed	3.07	5360
11	Perennial	Oil Palm	18	Irrigated	2.49	10400
12	Rabi	Rice	14	Irrigated	1.61	2660

4.1.3 Socioeconomic Status

4.1.3.1 Land holding pattern

The landholding pattern of farmers in the study area is presented in the Table 4.3. From the table, it was observed that marginal farmers (<1 ha) are the highest with 42.57% of the total farmers, having an average landholding of 0.54 ha followed by small farmers (1–2 ha) with 39.11% of the total farmers with an average landholding of 1.38 ha. Semi-medium farmers (2–4 ha) constitute 12.38% of the total farmers with an average landholding of 2.74 ha, while medium farmers (4–10 ha) account for 4.95% with an average landholding of 5.48 ha. Small number of farmers belong to the large farmer category (>10 ha) having 0.99% of the total farmer population with an average landholding of 11.2 ha. Average landholding size in the Dahanu watershed was found to be 1.63 ha, indicating that agriculture in the region is characterized by small and marginal landholdings. Such small farm sizes may limit farm mechanization, capital investment capacity, irrigation development and the adoption of improved agricultural technologies.

Table 4.3 Land holding pattern in Dahanu watershed

Classification	Criteria Land (ha)	No. of Farmers Interviewed (n)	Farmers (%)	Average Land Holding (ha)
Marginal Farmers	<1	86	42.57	0.54
Small Farmers	1–2	79	39.11	1.38
Semi-Medium Farmers	2–4	25	12.38	2.74
Medium Farmers	4–10	10	4.95	5.48
Large Farmers	>10	2	0.99	11.2
Average Land Holding				**1.63**

4.1.3.2 Income distribution

The income distribution from different crops in the watershed is presented in the Table 4.4. Rice occupies the largest cropped area (38.62%) with an average income of 72,480 Rs, indicating its importance as the major staple crop in the watershed. However, compared to horticultural crops, the income generated from Rice is moderate. Among horticultural crops, Banana has the highest average income of 2,98,700 Rs with a 4.63% of the total cropped area, indicating its high economic potential. Mango has 11.71% of the cropped area and provides an average income of 2,14,600 Rs, while Sapota occupies 5.29% with an average income of 1,76,500 Rs. Cashew has 9.96% of the cropped area with an average income of 1,56,900 Rs. Coconut and Arecanut covers 7.32% and 5.85% of the cropped area respectively, with average incomes of 1,48,400 Rs and 1,32,700 Rs. Chili, covers small area (3.49%) with an average income of 96,300 Rs. The results indicate that Rice has the largest cropped area and horticultural crops such as Banana, Mango, Cashew, and Sapota contribute significantly higher income to farmers.

Table 4.4 Average annual income of farmers in Dahanu watershed

Name of Crops	No. of Farmers Interviewed (n)	Crop Area (%)	Average Income (Rs.)
Rice	164	38.62	72,480
Mango	72	11.71	214,600
Cashew	61	9.96	156,900
Banana	31	4.63	298,700
Sapota	34	5.29	176,500
Coconut	44	7.32	148,400
Arecanut	39	5.85	132,700
Chilli	26	3.49	96,300

4.1.3.3 Education

The educational profile of the population in the villages of the watershed is presented in the Table 4.5, village Sogwe recorded the highest illiteracy rate (53%), followed by Arapada (52%), Halapada (50%), Paraspada (49%) and Chirakot (48%), indicating the majority of the population is without formal education in these villages. Other villages such as Varkande (47%), Dawadi (46%), Jamset (45%), Kotabi (44%) and Kubale (44%), Bramhanwadi (43%), Borwadi (42%), Ambesarai (41%) and Vankas (41%) also showed significant illiteracy. Lower illiteracy was observed in Dapchiri (39%), Bahare (38%), and Vasantwadi (36%) as compared to other villages. Vasantwadi recorded the highest population with primary education (31%), followed by Dapchiri and Bahare (30%), Ambesarai (29%), Vankas (29%) and Borwadi (29%). With respect to secondary education, the highest was recorded in Bahare and Vasantwadi (20%), followed by Dapchiri and Vankas (19%).For higher secondary education, majority of villages recorded between 6–9%, with Vasantwadi having the highest (9%), while village Kotabi, Ambesarai, Bramhanwadi, Dapchiri and Bahare reported 8%. The respondents with higher studies are low in all villages, ranged between 3 to 4%. The results indicate that the watershed is characterized by a low-literacy population with moderate primary and secondary education, while a small population has attained higher education. This educational pattern influence awareness levels, adoption of improved agricultural practices, and participation in developmental and extension activities within the watershed.

Table 4.5 Education profile of villages in Dahanu watershed by population

Village	No Education (%)	Primary (%)	Secondary (%)	Higher Secondary (%)	Higher Studies (%)
Kotabi	44	27	17	8	4
Chirakot	48	26	16	7	3
Dawadi	46	28	15	7	4
Arapada	52	24	14	7	3
Ambesarai	41	29	18	8	4
Paraspada	49	25	16	7	3
Bramhanwadi	43	27	18	8	4
Dapchiri	39	30	19	8	4
Halapada	50	26	15	6	3
Kubale	44	28	17	7	4
Varkande	47	26	16	7	4
Bahare	38	30	20	8	4
Vankas	41	29	19	7	4
Sogwe	53	24	14	6	3
Jamset	45	27	17	7	4
Borwadi	42	29	18	7	4
Vasantwadi	36	31	20	9	4

4.2 Land-use/Land-cover

The Land Use Land Cover (LULC) classification of the area reveals that agriculture is the predominant land use type, occupying 9699.4 ha, and constitutes approximately 70.5% of the total area (Table 4.6 and Fig. 4.1). Forested land covers accounts for 25.5% of the landscape, indicating a moderate presence of natural vegetation. Wastelands represent 5.6 ha of the area, which may indicate land degradation or areas unsuitable for cultivation. Waterbodies are limited to 380.5 ha, making up 2.8% of the total area, reflecting the presence of limited surface water resources in the region. This LULC distribution highlights the dominance of agricultural activities in the area with secondary coverage by forest and waterbody categories.

Table 4.6 Land-use/land-cover statistics of Dahanu watershed

Land use	Area (ha)	Percent (%)
Agriculture	9699.4	70.5
Forest	3510.7	25.5
Waterbody	380.5	2.8
Habitation	156.9	1.1
Wasteland	5.6	0.0
Total	**13753.12**	**100.00**

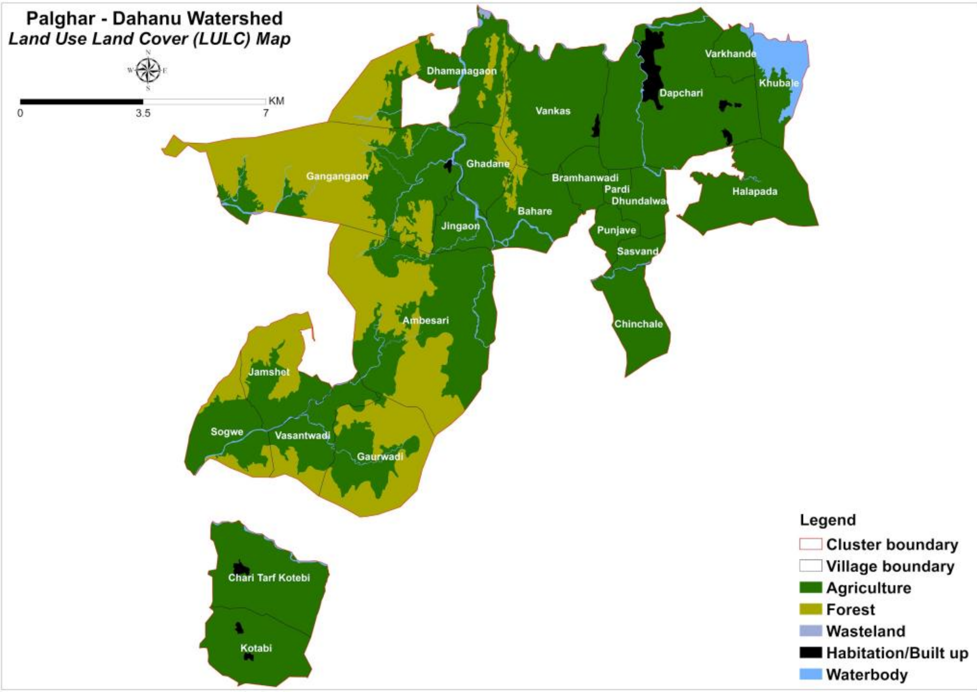


Fig. 4.1: Land-use/land-cover map

4.3 Landform Delineation

The landform analysis of the Dahanu watershed reveals a diverse geomorphological setting characterized by both erosional and depositional features. The pediment, representing gently sloping rock surfaces, is the most extensive landform, covering 4,473.6 ha (32.5%) of the total area. This is followed by Hills & Ridges, which encompass 3,310.3 ha (24.1%), reflecting a significant presence of undulating and elevated terrain. The pediplain covers 2,135.9 ha (15.5%), while the valley regions account for 1,924.7 ha (14.0%). Other notable features include the Foot Hills, spanning 630.30 ha (4.6%), and the Plateau Top, which occupies 540.6 ha (3.9%). Minor features such as Waterbodies (2.8%), Isolated Mounds (1.5%), and Habitations (1.1%) complete the landscape. Overall, the watershed is dominated by pediment and hilly terrains, indicating a complex topographical structure.

Table 4.7: Landform features existing in Dahanu watershed

Sr. no	Landform	Area(ha)	Percent (%)
1	Plateau Top	540.57	3.93
2	Hills & Ridges	3310.32	24.07
3	Foot Hill	630.30	4.58
4	Valley	1924.67	13.99
5	Pediment	4473.59	32.53
6	Pediplain	2135.92	15.53
7	Isolated Mound	200.40	1.46
8	Habitation/Built-up	156.90	1.14
9	Waterbody	380.46	2.77
	Total	**13753.12**	**100.00**

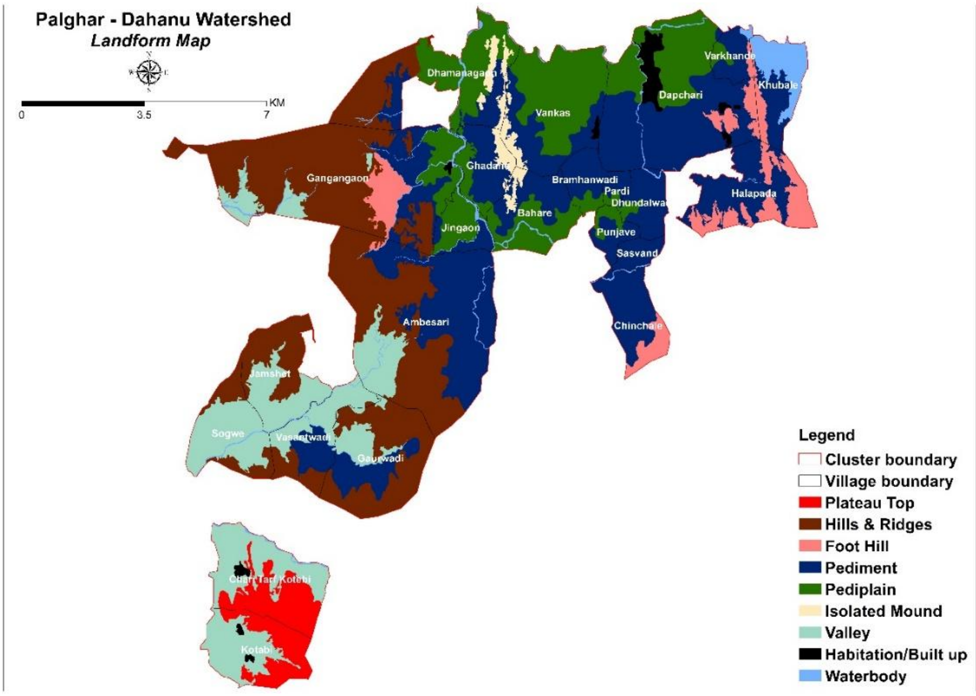


Fig. 4.2: Landform map of Dahanu watershed

4.4 Soil series and phases

Eleven soil series have been identified and mapped with 33 soil mapping units (phases of series) (Fig. 4.3). The detailed descriptions of each series are given in Table 4.8.

Table 4.8. Dominant soil series identified in the watershed

Sr. No.	Soil Series	Area (ha)	Percent (%)
1	Babara	1555.72	11.31
2	Baripada	1732.56	12.60
3	Basanbasi	2179.70	15.85
4	Chari	1155.62	8.40
5	Gagon	380.43	2.77
6	Patharpada	531.11	3.86
7	Sagpada	568.53	4.13
8	Uganipada	391.23	2.84
9	vankesh	1095.58	7.97
10	Varkhand	1644.37	11.96
11	Wagheipada	1980.91	14.40
12	Habitation/Built-up	156.90	1.14
13	Waterbody	380.46	2.77
	Total	**13753.12**	**100.00**

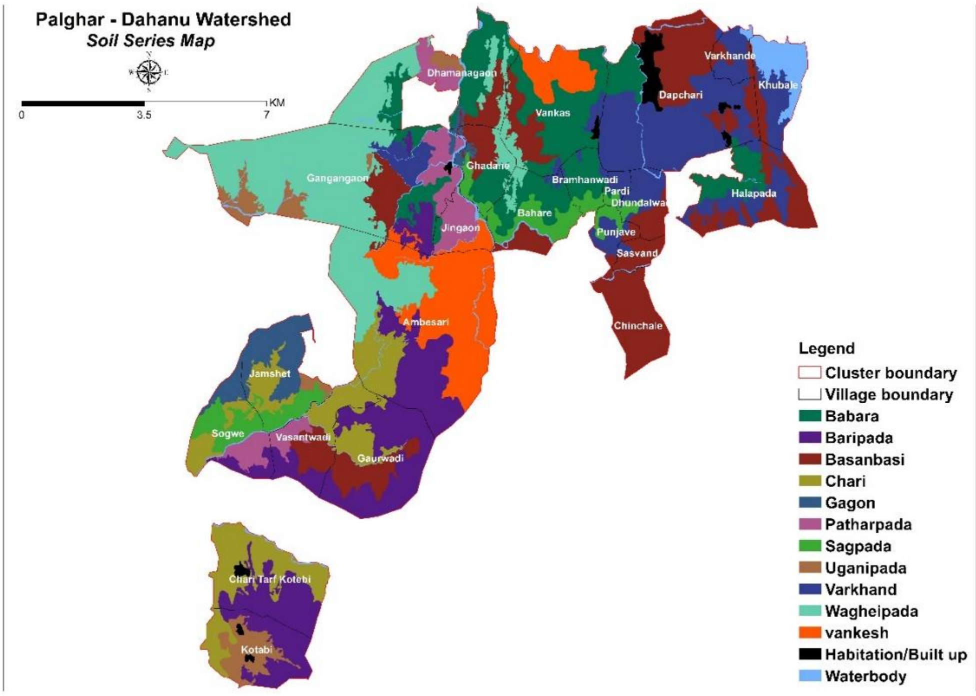


Fig. 4.3: Soil series map of Dahanu watershed.

Table 4.9. Soil phases existing in Dahanu watershed

Sr. No.	Phase	Area(ha)	Percent (%)
1	Bab4mC2	473.780883	3.44
2	Bab4mD1	965.769136	7.02
3	Bab4mD3	116.165223	0.84
4	Bar1mF4	551.273113	4.01
5	Bar1mG4	1181.28755	8.59
6	Bas1dD3	390.919699	2.84
7	Bas1fC1	196.075682	1.43
8	Bas1fC2	75.266738	0.55
9	Bas1fC3	387.72396	2.82
10	Bas1gD2	186.518765	1.36
11	Bas1mD2	703.822992	5.12
12	Bas1mD3	239.376078	1.74
13	Chr2fC2	69.675524	0.51
14	Chr2mC2	607.412631	4.42
15	Chr2mD2	478.529121	3.48
16	Gag2gD4	42.611546	0.31
17	Gag2mF3	337.818811	2.46
18	Pat6mC1	253.336897	1.84
19	Pat6mD1	277.776127	2.02
20	Sag6mC1	568.529383	4.13
21	Uga3mC1	187.08969	1.36
22	Uga4fC1	35.570163	0.26

23	Uga4mC1	168.568359	1.23
24	Van6gD2	879.015331	6.39
25	Van6mC1	216.569147	1.57
26	Var2gC2	0.37604	0.00
27	Var2kD2	322.068668	2.34
28	Var2mB2	508.01829	3.69
29	Var2mC1	30.945739	0.23
30	Var2mC2	340.237455	2.47
31	Var2mD2	442.725508	3.22
32	Wag3kD2	200.395937	1.46
33	Wag3kD4	1780.512005	12.95
34	Habitation/Built-up	156.90	1.14
35	Waterbody	380.46	2.77
	Total	**13753.12**	**100.00**

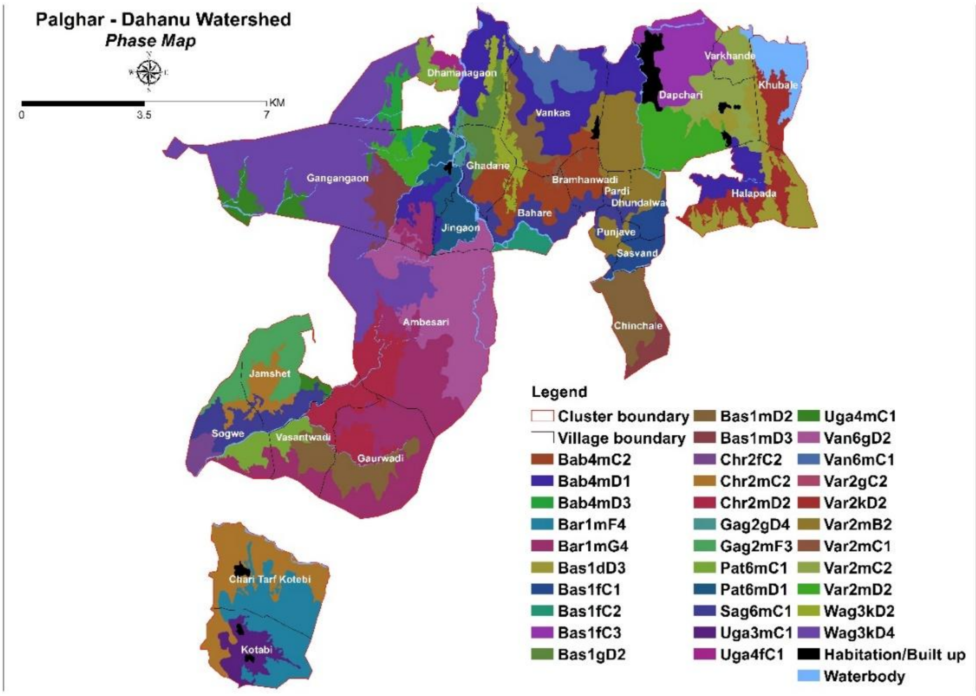


Fig. 4.4: Soil Phase map of Dahanu watershed

4.5 Soil Survey Interpretation

4.5.1 Slope

Land slope plays a crucial role in agriculture, as it affects water drainage, soil erosion, and the ease with which crops can be cultivated. Steep slopes tend to have higher rates of surface runoff, which can lead to soil erosion and loss of valuable topsoil, reduce soil fertility and compromise crop yields. On the other hand, flat or gently sloping lands allow for better water retention, easier mechanization, and more efficient irrigation practices, leading to higher productivity. The slope also influences the microclimate of the area, with sloped terrains potentially being more prone to temperature extremes or frost in certain regions. By considering the slope of land, farmers can implement soil conservation techniques, such as terracing, bunding or contour farming, to reduce erosion and optimize land use, ensuring more sustainable agricultural practices. Among the different slope classes (Table 4.10, Fig. 4.5) the maximum area of watershed is under moderately sloping (8-15%) i.e. 38.14% followed by moderately steep sloping sloping (15 - 30%) i.e. 28%, gently sloping (3 - 8%) i.e. 26.26%, and very gently sloping (1 - 3%) i.e. 3.69%.

Table 4.10: Land slope classes in Dahanu watershed

Sr. No.	Slope Class (%)	Area (ha)	TGA (%)
1	Very gently sloping (1 - 3)	508.02	3.69
2	Gently sloping (3 - 8)	3611.16	26.26
3	Moderately sloping (8 - 15)	5245.69	38.14
4	Moderately steep sloping (15 - 30)	3850.89	28.00
5	Habitation/Built-up	156.90	1.14
6	Waterbody	380.46	2.77
	Total	**13753.12**	**100.00**

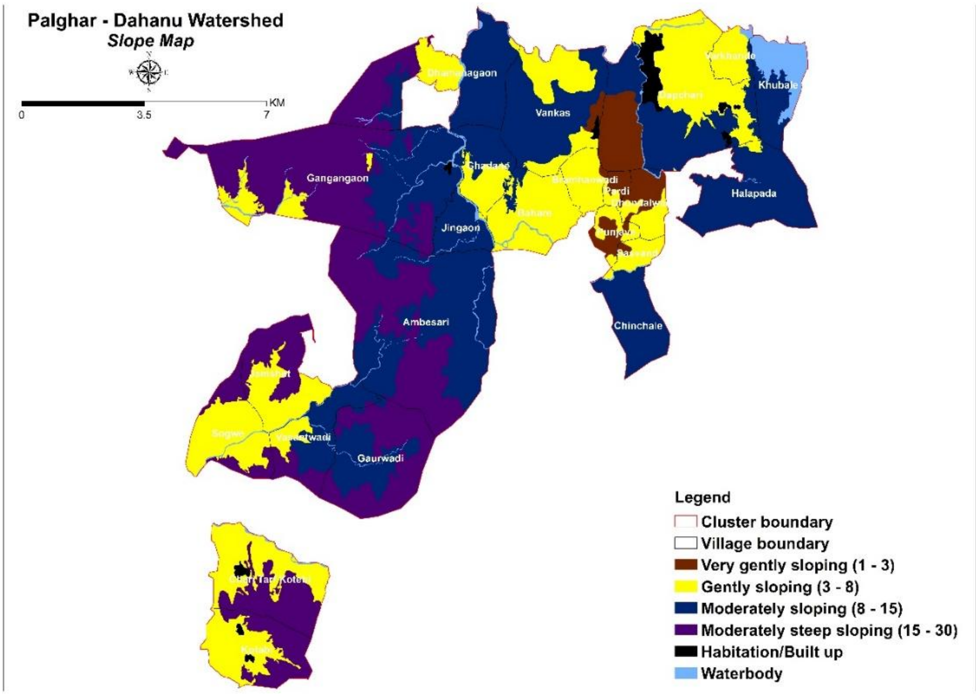


Fig. 4.5: Slope map of Dahanu watershed

4.5.2 Soil Erosion

Soil erosion by water or wind removes fertile topsoil, reducing the land's ability to grow crops and store water. Over time, this leads to lower agricultural yields and the buildup of sediment in nearby rivers and lakes. To stop this, techniques like building terraces, planting cover crops, and using mulch are essential. About 21.1% (2900.2 ha) has very slight erosion, while 38.45% (5287.84 ha) is moderate. However, a significant 36.55% (5027.68

ha) faces Severe to Very Severe erosion. These high-risk zones demand immediate prioritization for mechanical and biological conservation.

Table 4.11: Soil erosion status in Dahanu watershed

Sr. No.	Erosion class	Area (ha)	Percent (%)
1	Very Slight	2900.2	21.1
2	Moderate	5287.8	38.4
3	Severe	1472.0	10.7
4	Very Severe	3555.7	25.9
5	Habitation/Built-up	156.9	1.1
6	Waterbody	380.5	2.8
	Total	**13753.1**	**100.0**

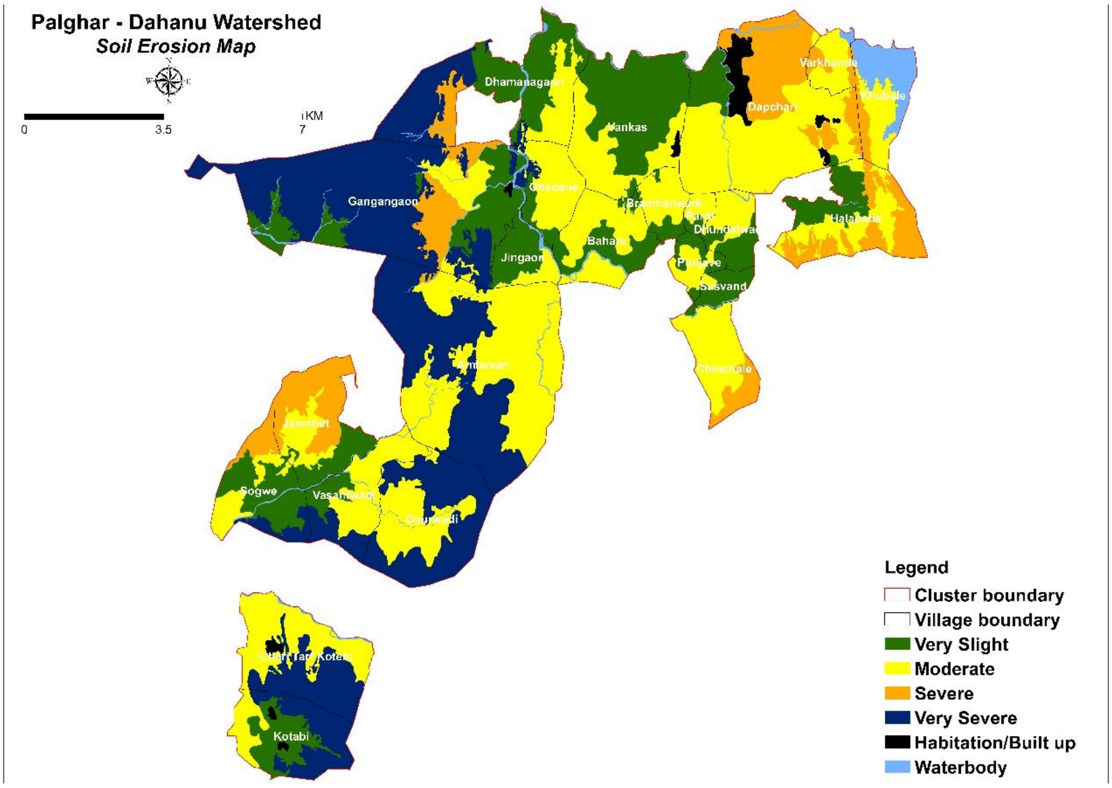


Fig. 4.6: Erosion map of Dahanu watershed

4.5.3 Soil Depth

Soil depth is a critical factor in agriculture as it acts as an integrative proxy for several other soil properties and functions, including soil moisture retention, organic carbon storage, effective rooting depth, nutrient availability, and overall profile development. These properties are intrinsically linked to pedogenic processes such as weathering, translocation, erosion-deposition dynamics, and biological activity, all of which are strongly modulated by landscape position and hydrological regime. As a result, spatial variability in soil depth reflects not only physical soil thickness but also broader gradients in soil fertility, water holding capacity, and ecosystem functioning across the terrain. Deeper soils generally provide more space for roots to penetrate, access water, and take up essential nutrients, which supports healthier plant growth and higher crop yields. Shallow soils, on the other hand, can restrict root development and limit the availability of nutrients and moisture, especially during dry periods. This can result in stunted plant growth, lower productivity, and increased vulnerability to drought stress. In regions with shallow soils, farmers may need to implement practices such as deep ploughing, irrigation, or the addition of organic matter to improve soil depth and enhance crop performance. Understanding soil depth helps farmers make better decisions on crop selection, irrigation, and soil management, promoting more efficient and sustainable agricultural practices. The soil depth within the watershed (Fig. 4.7) ranges from shallow (<25 cm) to very deep (>100 cm). According to the area distribution presented in Table 4.12, shallow soils cover the largest share (28.45%), followed by moderate (23.13%), very deep (16.22%), moderately deep (14.40%), and deep soils (13.90%).

Table 4.12. Soil depth classes in Dahanu watershed

Sr. No.	Depth Class (cm)	Area (ha)	TGA (%)
1	Shallow (< 25)	3912.26	28.45
2	Moderate (25 - 50)	3180.42	23.13
3	Moderately Deep (50 - 75)	1980.91	14.40
4	Deep (75 - 100)	1911.37	13.90
5	Very Deep (> 100)	2230.80	16.22
6	Habitation/Built-up	156.90	1.14
7	Waterbody	380.46	2.77
	Total	**13753.12**	**100.00**

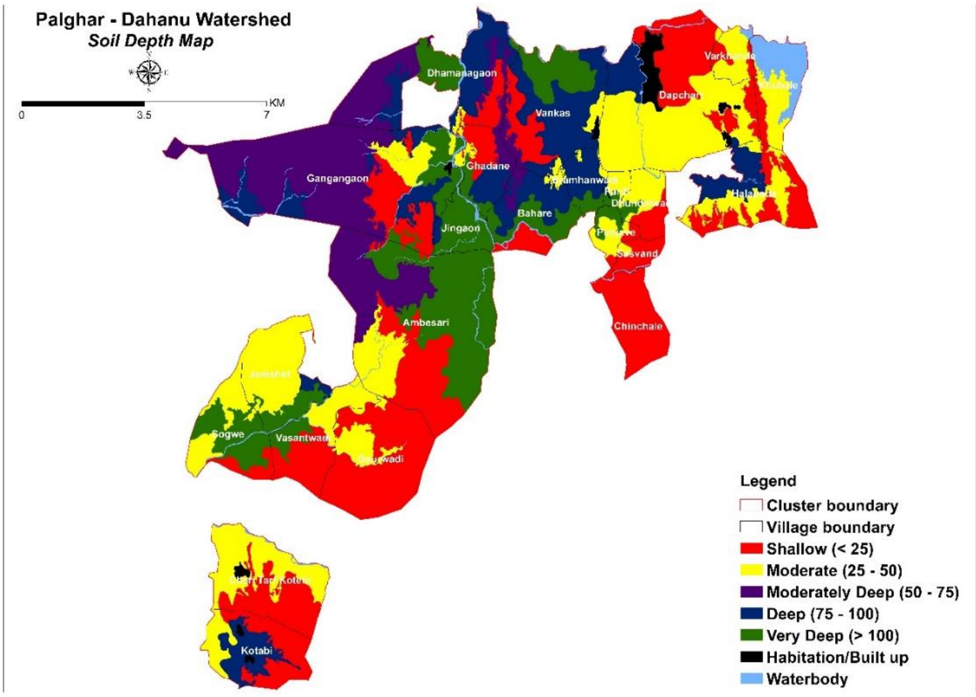


Fig. 4.7: Depth map of Dahanu watershed

4.5.4 Surface texture

Soil texture is a key physical property that influences water holding capacity, aeration, drainage, and nutrient availability in soils. It plays an important role in determining crop suitability, root penetration, and soil management practices. Fine-textured soils such as clay retain more moisture but may experience poor drainage and compaction, whereas medium-textured soils provide better conditions for plant growth by maintaining a balance between water retention and aeration. Therefore, understanding the spatial distribution of soil texture within a watershed is essential for effective agricultural planning and sustainable land management.

The surface soils of the Palghar–Dahanu watershed were categorized into six texture classes (Table 4.13). Clay was the most dominant texture, occupying 10,256.33 ha, which accounts for 74.57% of the total geographical area. This was followed by silty clay loam (8.06%), clay loam (5.56%), silty clay (5.06%), and loam (2.84%). In addition to these soil textures, habitation/built-up areas (1.14%) and water bodies (2.77%) were also identified within the watershed. The dominance of clay soils suggests a relatively high moisture-retaining capacity across the watershed area.

Table 4.13. Soil texture distribution in Dahanu watershed

Sr. No.	Texture	Area (ha)	TGA (%)
1	Clay	10256.33	74.57
2	Clay Loam	764.31	5.56
3	Loam	390.92	2.84
4	Silty Clay	695.68	5.06
5	Silty Clay Loam	1108.52	8.06
6	Habitation/Built-up	156.90	1.14
7	Waterbody	380.46	2.77
	Total	**13753.12**	**100.00**

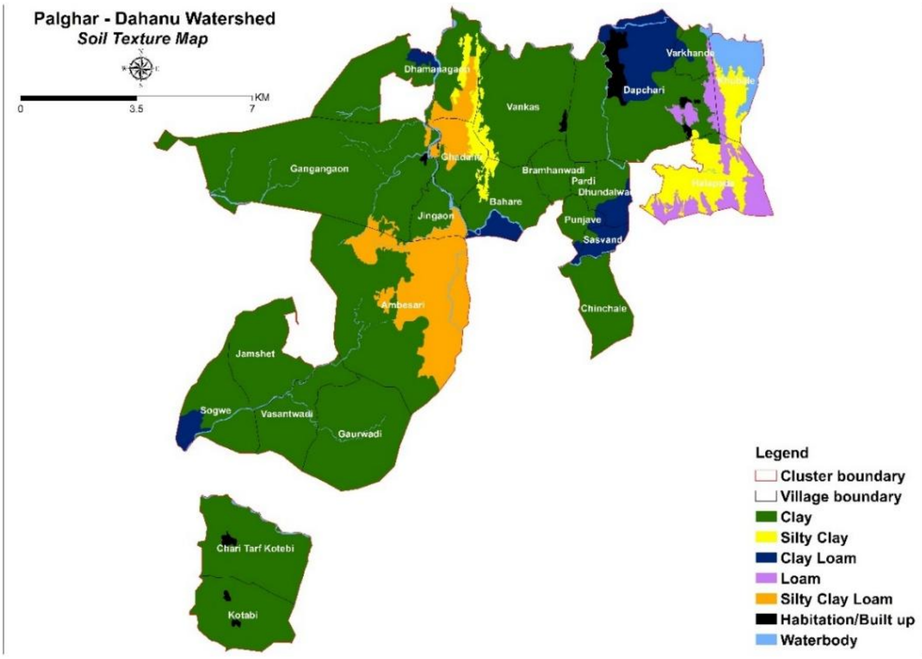


Fig. 4.8: Soil texture map of Dahanu watershed

4.5.5 Soil reaction

Soil reaction or pH, a measure of acidity or alkalinity, is crucial for plant health and growth because it directly impacts nutrient availability, microbial activity, and overall soil health, influencing crop yields and suitability. The analysis shows that neutral soils (pH 6.5–7.5) dominate the watershed, occupying 6,385.87 ha, which accounts for 46.43% of the total geographical area. This is followed by slightly acidic soils (25.67%) and moderately acidic soils (6.20%). Slightly alkaline soils cover 8.05%, while moderately alkaline soils occupy 9.74% of the area. Overall, the prevalence of neutral to slightly acidic soils indicate generally favorable conditions for agricultural production.

Table 4.14. Soil pH distribution in Dahanu watershed

Sr. No.	Soil pH	Area (ha)	TGA (%)
1	Moderately Acidic (5.0 - 6.0)	852.41	6.20
2	Slightly Acidic (6.0 - 6.5)	3530.76	25.67
3	Neutral (6.5 - 7.5)	6385.87	46.43
4	Slightly Alkaline (7.5 - 8.0)	1106.94	8.05
5	Moderately Alkaline (8.0 - 9.0)	1339.78	9.74
6	Habitation/Built-up	156.90	1.14
7	Waterbody	380.46	2.77
	Total	**13753.12**	**100.00**

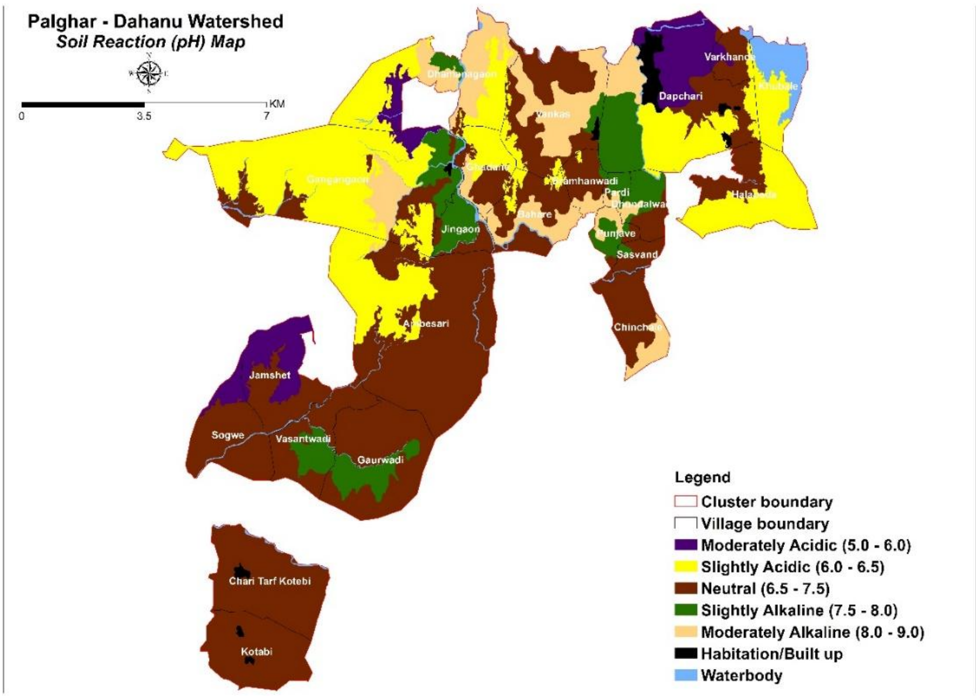


Fig. 4.9: Soil pH map of Dahanu watershed

4.5.6 Soil salinity

Soil salinity, measured through the electrical conductivity of a solution within a unit distance, represents the content of soluble salts in the matrix. Soil conductivity is an index to measure soil water-soluble salt, which is an important indicator of mineral nutrients in the topsoil that can be quickly utilized by plants and is a factor to determine whether salt ions in soil limit crop growth. The salinity status of soils in the watershed is summarized in Table 4.15. The analysis shows that almost the entire area falls under the normal salinity category (EC < 1 dS m^{-1}), covering 13,215.76 ha**,** which represents 96.09% of the total geographical area. The results indicate that the soils are largely free from salinity problems and are favorable for crop cultivation.

Table 4.15. Soil salinity classes in Dahanu watershed

Sr. No.	Electrical conductivity (dSm^{-1})	Area (ha)	TGA (%)
1	Normal (< 1)	13215.76	96.09
2	Habitation/Built-up	156.90	1.14
3	Waterbody	380.46	2.77
	Total	**13753.12**	**100.00**

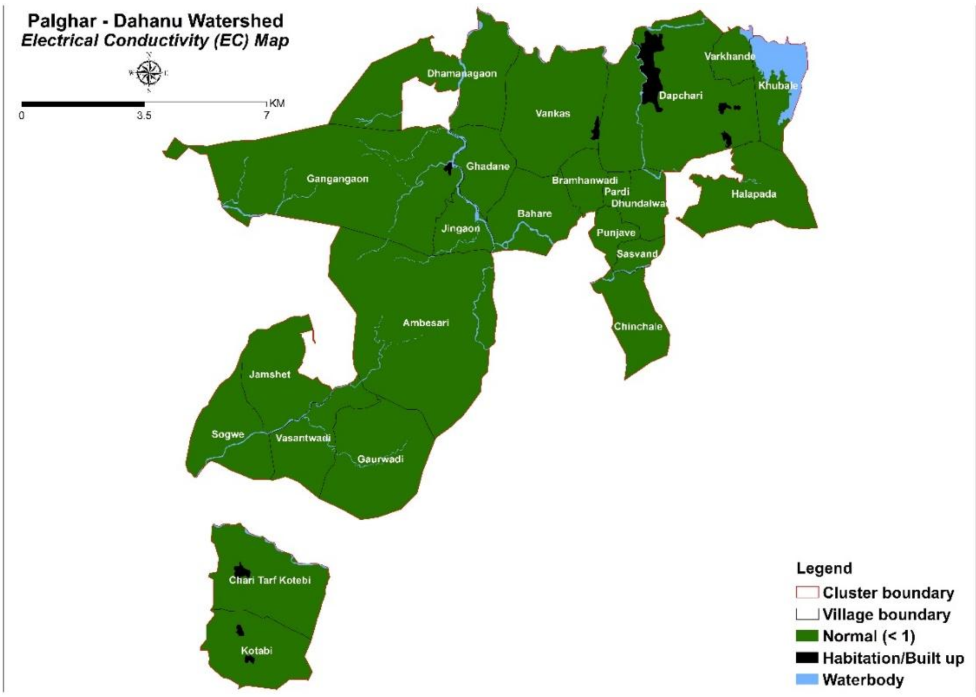


Fig. 4.10: Soil EC map of Dahanu watershed

4.5.7 Soil organic carbon

The soil organic carbon (SOC) is a critical component to several ecological processes, and is primarily derived from plant decomposition and animal residues, like leaves, roots, and dead organisms. It serves as a significant indicator of soil health and fertility. The SOC influences the soil's ability to retain and release essential nutrients, regulate water-holding capacity and support microbial activity. It also acts as a reservoir for carbon sequestration, helping mitigate climate change by removing carbon dioxide from the atmosphere.

Monitoring SOC levels is crucial for sustainable land use and management. The loss of SOC through practices like deforestation and intensive agriculture can result in degraded soils leading to reduced agricultural productivity and enhanced greenhouse gas emissions. Promotion of climate-smart practices that increase SOC can ensure healthier and productive soils. The distribution of SOC in the Palghar–Dahanu watershed is summarized in Table 4.16 and Fig 4.11 The results indicate that low SOC (0.21–0.40%) covers the largest portion of the watershed, accounting for 27.73% of the total area. This is followed by very high SOC (>1.00%) occupying 24.11%**.** Areas with very low SOC (<0.20%) and medium SOC (0.41–0.60%) represent 14.53% and 14.84%**,** respectively. High SOC (0.81–1.00%) and moderately high SOC (0.61–0.80%) occupy 10.56% and 4.33% of the area.

Table 4.16 Soil organic carbon status of Dahanu watershed

Sr. No.	Organic carbon (%)	Area (ha)	TGA (%)
1	Very Low (< 0.20)	1997.98	14.53
2	Low (0.21 - 0.40)	3814.20	27.73
3	Medium (0.41 - 0.60)	2040.46	14.84
4	Moderately High (0.61 - 0.80)	595.89	4.33
5	High (0.81 - 1.00)	1451.81	10.56
6	Very High (> 1.00)	3315.42	24.11
7	Habitation/Built-up	156.90	1.14
8	Waterbody	380.46	2.77
	Total	**13753.12**	**100.00**

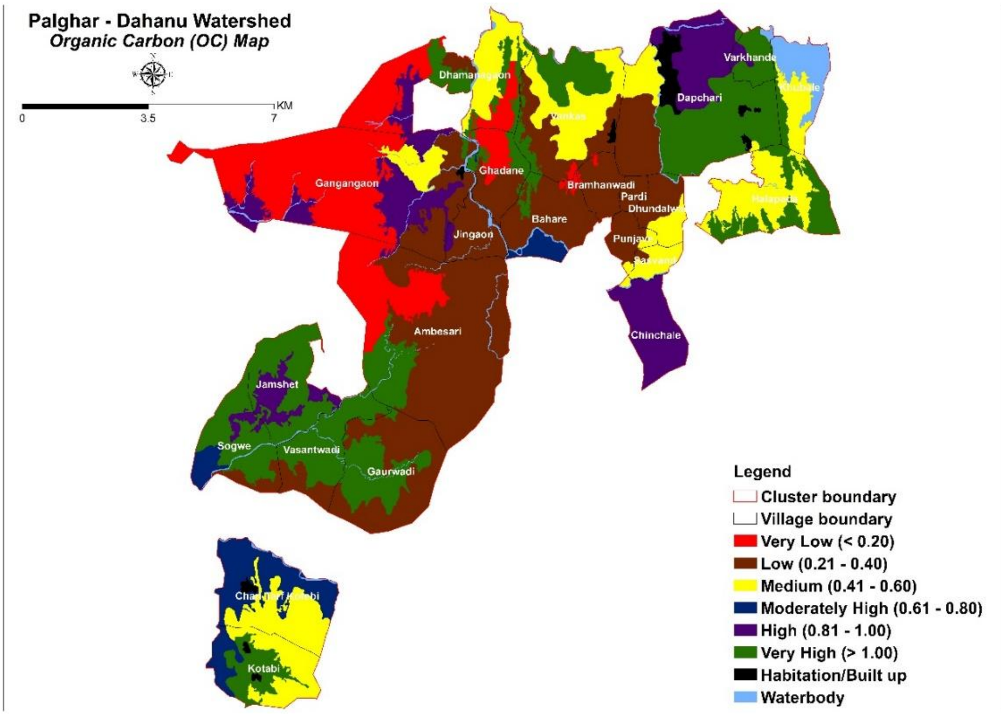


Fig. 4.11: Soil organic carbon map of Dahanu watershed

4.5.8 Available Nitrogen (N)

Available nitrogen content in soils is crucial as it forms the primary building block for plant growth, is essential for producing proteins, amino acids, and chlorophyll to support photosynthesis, plant health and yield. The distribution of available nitrogen (N) in the soils of the Palghar–Dahanu watershed is summarized in Table 4.17 and Fig. 4.12. The data reveal that low nitrogen content (141–280 kg ha^{-1}) is the predominant class, covering 9,350.42 ha**,** which represents 67.99% of the total watershed area. In contrast, very low nitrogen levels (<140 kg ha^{-1}) are observed in 3,865.34 ha (28.11%) of the area. Overall, the soils largely fall under low nitrogen status, suggesting the need for proper nitrogen management to support sustainable crop production.

Table 4.17: Available N content in soils of Dahanu watershed

Sr. No.	Available N (kg ha^{-1})	Area (ha)	TGA (%)
1	Very Low (< 140)	3865.34	28.11
2	Low (141 - 280)	9350.42	67.99
3	Habitation/Built-up	156.90	1.14
4	Waterbody	380.46	2.77
	Total	**13753.12**	**100.00**

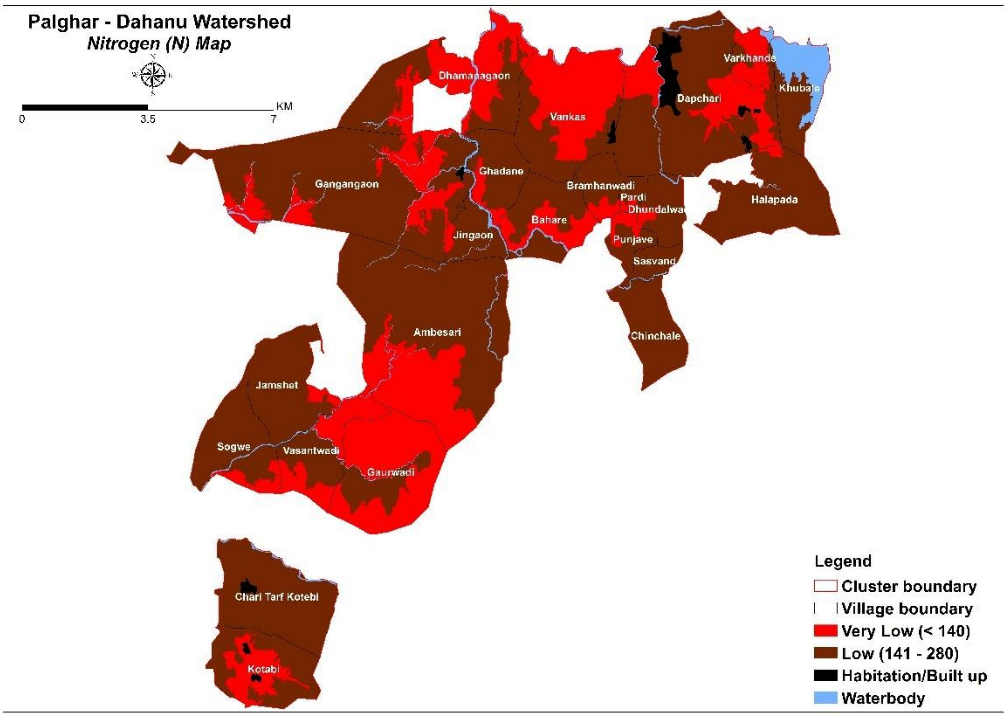


Fig. 4.12: Available soil nitrogen map of Dahanu watershed

4.5.9 Available Phosphorous (P)

Among the three major nutrients, phosphorus (P) plays an important role to complete the life cycle of a plant; its functions start right from the stimulation of root growth to proper seed filling and seed setting. It also plays a vital role in photosynthesis, carbohydrate breakdown and transfer of energy in the form of ATP and ADP compounds in various metabolic processes. The P content of the agricultural soils of the watershed is illustrated in Table 4.18 and Fig. 4.13. The results reveal notable variability in phosphorus availability throughout the watershed. The low phosphorus category (16–30 kg ha^{-1}) covers the largest proportion of the area, extending over 5,004.24 ha, which constitutes about 36.39% of the total geographical area. This is followed by the very low phosphorus class (<15 kg ha^{-1}), occupying 4,733.67 ha or 34.42% of the watershed. Soils with medium phosphorus levels (31–50 kg ha^{-1}) account for approximately 21.85% of the total area.

In comparison, areas with moderately high phosphorus content (51–65 kg ha^{-1}) are relatively limited, covering only 3.44% of the watershed. The overall distribution pattern indicates that a significant portion of the watershed is characterized by very low to low phosphorus availability. This suggests the necessity for appropriate nutrient management practices, particularly the judicious use of phosphatic fertilizers, to enhance soil fertility and support sustainable agricultural production in the region.

Table 4.18: Available P content in soils of Dahanu watershed

Sr. No.	Available P (kg ha^{-1})	Area (ha)	TGA (%)
1	Very Low (< 15)	4733.67	34.42
2	Low (16 - 30)	5004.24	36.39
3	Medium (31 - 50)	3005.09	21.85
4	Moderately High (51 - 65)	472.77	3.44
5	Habitation/Built-up	156.90	1.14
6	Waterbody	380.46	2.77
	Total	**13753.12**	**100.00**

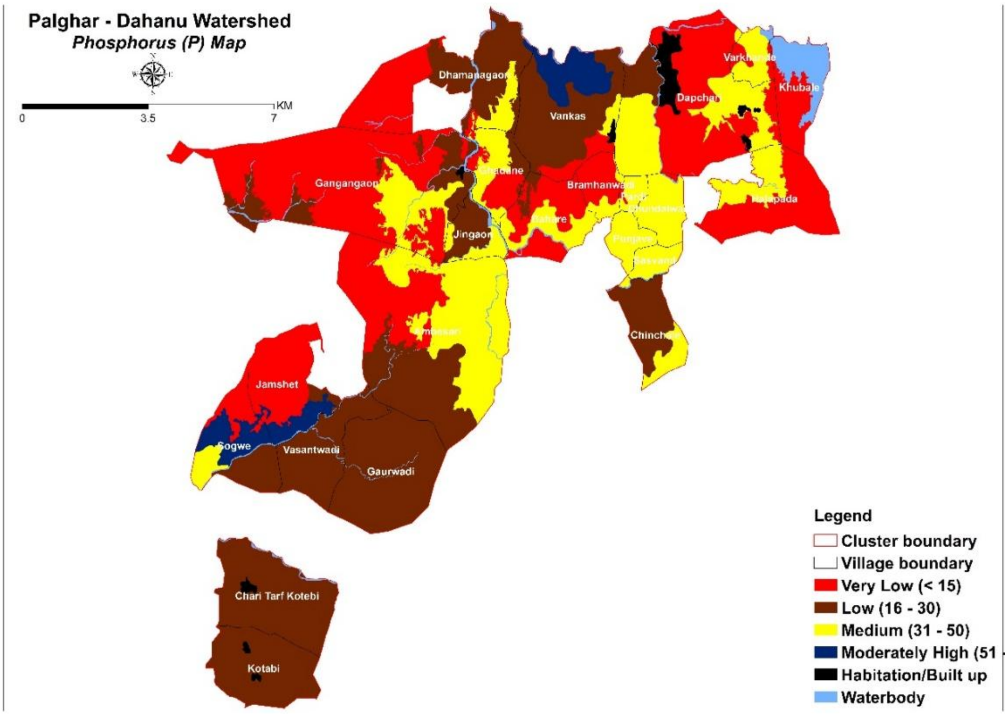


Fig.4.13: Available soil Phosphorus map of Dahanu watershed

4.5.10 Available Potassium (K)

The importance of potassium (K) is well recognized in agriculture. Exchangeable K or available K is widely used to evaluate the soil K status and to predict the crop K requirements. The distribution of available potassium (K) in the soils of the Palghar–Dahanu watershed is depicted in Table 4.19 and Fig. 4.14. The analysis indicates that a major portion of the watershed possesses very high potassium content (>360 kg ha^{-1}), covering 7,752.44 ha and accounting for 56.37% of the total geographical area. Soils with high (301–360 kg ha^{-1}) and moderately high (241–300 kg ha^{-1}) potassium levels cover 9.73% and 7.09% of the area, respectively. In contrast, low (121–180 kg ha^{-1}) and very low (<120 kg ha^{-1}) potassium classes occupy 10.38% and 9.19% of the watershed. Medium potassium status accounts for 3.35%.

Table 4.19: Available K content of soils of Dahanu watershed

Sr. No.	Available K (kg ha^{-1})	Area (ha)	TGA (%)
1	Very Low (< 120)	1263.72	9.19
2	Low (121 - 180)	1427.04	10.38
3	Medium (181 - 240)	460.14	3.35
4	Moderately High (241 - 300)	974.65	7.09
5	High (301 - 360)	1337.77	9.73
6	Very High (> 360)	7752.44	56.37
7	Habitation/Built-up	156.90	1.14
8	Waterbody	380.46	2.77
	Total	**13753.12**	**100.00**

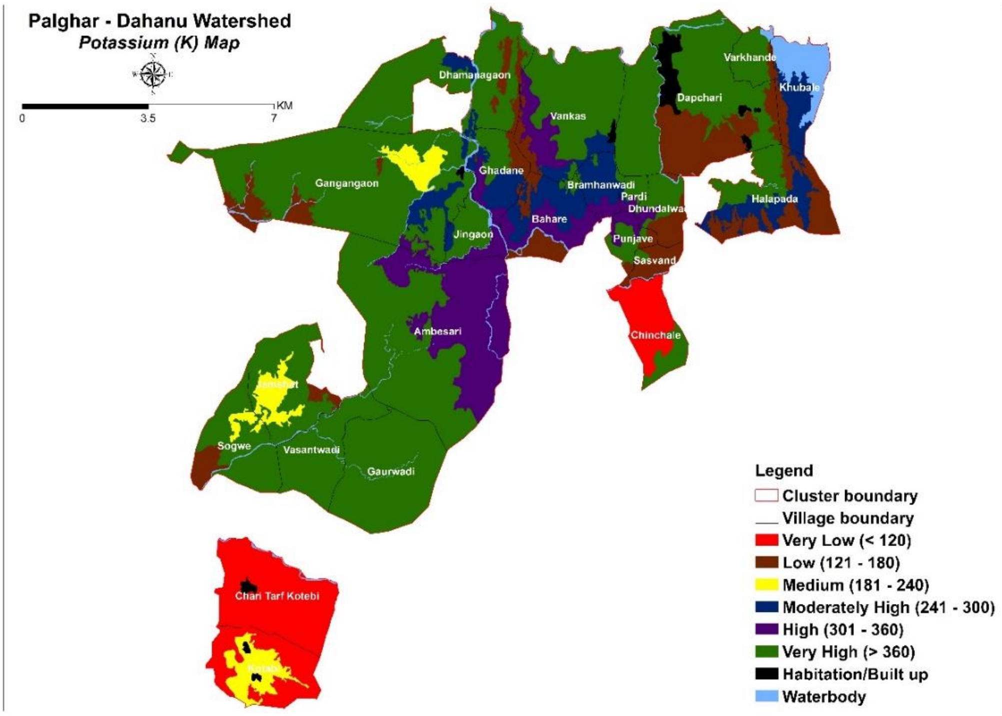


Fig. 4.14: Available soil Potassium map of Dahanu watershed

4.5.11 Micronutrient status of soils

Although required in relatively small amounts, micronutrients play an essential role in maintaining soil fertility and sustaining plant growth. Iron (Fe), manganese (Mn), copper (Cu) and zinc (Zn) were analyzed as DTPA-extractable forms to assess their availability in the soils of the Palghar–Dahanu watershed. These micronutrients are involved in several important physiological functions such as photosynthesis, enzyme activation, respiration and nitrogen fixation. Deficiency of any of these nutrients may adversely affect plant growth, crop yield and quality. Therefore, assessment of their spatial distribution is necessary for proper nutrient management and balanced fertilization.

The available Fe content of the watershed soils (Table 4.20; Fig. 4.15) shows that about 26.59% of the area falls under very low to low categories, indicating Fe deficiency in some parts of the watershed. The majority of the area occurs under the medium (30.25%) and moderately high (17.90%) classes, while 13.10% and 8.24% of the area fall under high and very high categories, respectively. Manganese distribution (Table 4.21; Fig. 4.16) indicates that most soils are adequately supplied with Mn, with 48.17% of the area under very high and 35.00% under medium categories. Copper status (Table 4.22; Fig. 4.17) reveals that the entire watershed is sufficient in Cu, with 81.50% of the area under very high and 14.59% under high categories. In contrast, zinc availability (Table 4.23; Fig. 4.18) indicates widespread deficiency, with 59.76% of the area under very low and 14.30% under low categories, suggesting the need for Zn fertilization to enhance crop productivity and maintain soil health.

Table 4.20: Available Fe content in the soils of Dahanu watershed

Sr. No.	Available Fe (mg kg^{-1})	Area (ha)	TGA (%)
1	Very Low (< 2.5)	2153.48	15.66
2	Low (2.5 - 4.5)	1503.81	10.93
3	Medium (4.5 - 6.5)	4160.31	30.25
4	Moderately High (6.5 - 8.5)	2462.33	17.90
5	High (8.5 - 10.5)	1802.25	13.10
6	Very High (> 10.5)	1133.59	8.24
7	Habitation/Built-up	156.90	1.14
8	Waterbody	380.46	2.77
	Total	**13753.12**	**100.00**

Table 4.21: Available Mn content in the soils of Dahanu watershed

Sr. No.	Available Mn (mg kg^{-1})	Area (ha)	TGA (%)
1	Medium (1.3 - 5.0)	4813.96	35.00
2	Moderately High (5.0 - 7.0)	1303.78	9.48
3	High (7.0 - 9.0)	473.45	3.44
4	Very High (> 9.0)	6624.58	48.17
5	Habitation/Built-up	156.90	1.14
6	Waterbody	380.46	2.77
	Total	**13753.12**	**100.00**

Table 4.22: Available Cu content in the soils of Dahanu watershed

Sr. No.	Available Cu (mg kg^{-1})	Area (ha)	TGA (%)
1	High (0.8 - 1.0)	2006.65	14.59
2	Very High (> 1.0)	11209.11	81.50
3	Habitation/Built-up	156.90	1.14
4	Waterbody	380.46	2.77
	Total	**13753.12**	**100.00**

Table 4.23: Available Zn content in the soils of Dahanu watershed

Sr. No.	Available Zn (mg kg^{-1})	Area (ha)	TGA (%)
1	Very Low (< 0.3)	8219.06	59.76
2	Low (0.3 - 0.6)	1966.19	14.30
3	Medium (0.6 - 0.9)	1014.00	7.37
4	Moderately High (0.9 - 1.2)	42.61	0.31
5	High (1.2 - 1.8)	1698.95	12.35
6	Very High (> 1.8)	274.95	2.00
7	Habitation/Built-up	156.90	1.14
8	Waterbody	380.46	2.77
	Total	**13753.12**	**100.00**

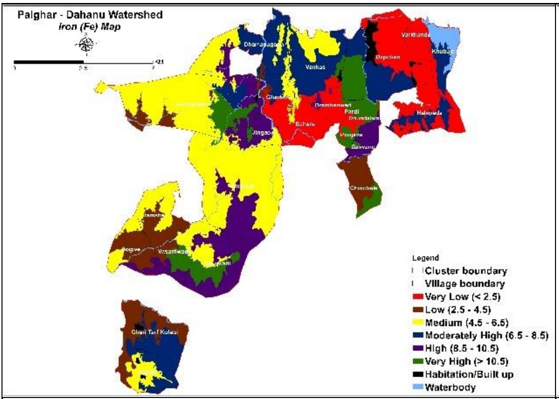


Fig. 4.15: DTPA-extractable soil Fe map of Dahanu watershed

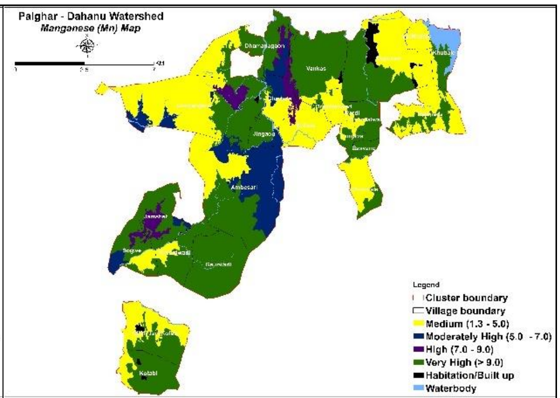


Fig. 4.16: DTPA-extractable soil Mn map of Dahanu watershed

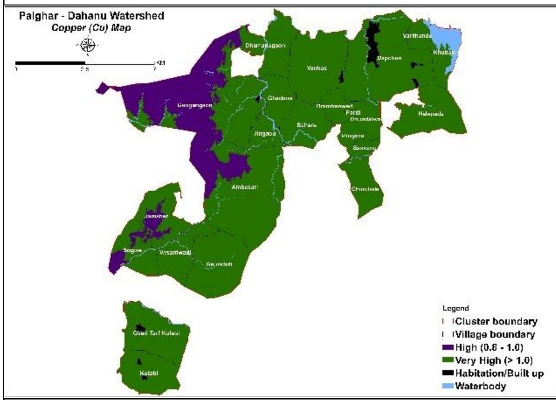


Fig. 4.17: DTPA-extractable soil Cu map of Dahanu watershed

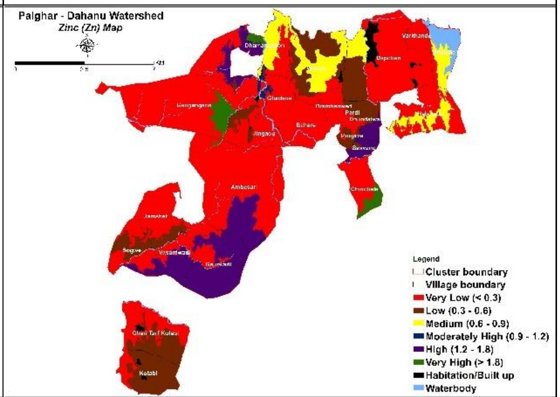


Fig. 4.18: DTPA-extractable soil Zn map of Dahanu watershed

4.6 Surface Runoff

Surface runoff estimation for the cluster watershed in Dahanu Taluka, Palghar District, provides important insight into the hydrological response of the landscape to intense seasonal monsoon rainfall. In humid tropical environments, a significant proportion of precipitation occurs during the southwest monsoon, resulting in substantial surface runoff due to high rainfall intensity and short-duration storm events. While a part of the rainfall infiltrates into the soil and contributes to soil moisture storage and groundwater recharge, a considerable fraction flows as surface runoff through natural drainage channels. This runoff plays an important role in redistributing water across the landscape, transporting sediments, and contributing to groundwater recharge along drainage pathways and water harvesting structures. To evaluate the hydrological behavior of the Dahan watershed in Palghar district, historical rainfall and derived runoff data for the period 2014-24 were analysed to assess both temporal and seasonal variability in runoff generation. Monthly rainfall and runoff during the monsoon period (June-October) are presented in Table 4.24, while the annual rainfall-runoff characteristics, including the number of runoff events and runoff percentage, are summarized in Table 4.25. Analysis of rainfall and runoff data for the period 2014–24 indicates that early monsoon rainfall in June, averaging 452.7 mm across the 22 villages, generates 193.8 mm of runoff, reflecting initial soil absorption. Runoff rises sharply in July, with average rainfall of 1037.2 mm producing 584.5 mm of runoff, which constitutes the largest share of seasonal runoff. August rainfall of 542.0 mm generates 237.4 mm of runoff on average, while September rainfall of 462.5 mm produces 197.6 mm of runoff. By October, runoff is negligible (0.15 mm) against an average rainfall of 42.5 mm, as most precipitation is absorbed or utilized. The analysis indicates considerable inter-annual as well as monthly variability in rainfall and runoff behaviour within the watershed.

Table 4.24 Details of Monthly (June-Oct) runoff (mm) for the period 2014-24

Year/Month	June		July		Aug		Sept		Oct	
	Rainfall (mm)	Runoff (mm)	Rainfall (mm)	Runoff (mm)	Rainfall (mm)	Runoff (mm)	Rainfall (mm)	Runoff (mm)	Rainfall (mm)	Runoff (mm)
2014	102.6	5.7	1298.4	796.6	358.2	67.9	272.6	92.5	1.4	0.0
2015	642.4	308.9	454.4	211.1	149.6	0.0	195.5	50.0	6.0	0.0
2016	551.8	321.7	1134.6	606.5	880.7	494.0	914.2	535.1	87.5	1.0
2017	695.2	314.0	1064.7	572.4	578.2	258.7	329.0	196.8	80.7	0.7
2018	630.5	368.5	1324.6	841.4	234.6	12.6	26.1	0.0	11.0	0.0
2019	348.9	171.7	1191.8	741.3	557.4	274.6	966.8	496.4	56.9	0.0
2020	161.6	0.1	548.8	162.0	1458.1	864.9	137.6	7.6	46.5	0.0
2021	537.3	144.7	615.3	265.6	504.7	168.9	943.1	434.4	38.6	0.0
2022	322.5	104.3	1355.7	850.6	489.6	197.7	568.7	221.1	63.6	0.0
2023	561.9	295.2	1287.1	733.1	138.0	0.6	225.9	17.7	12.9	0.0
2024	425.2	97.6	1133.4	648.7	612.6	271.6	508.3	121.8	62.5	0.0
Average	**452.72**	**193.85**	**1037.16**	**584.48**	**541.97**	**237.41**	**462.53**	**197.58**	**42.51**	**0.15**

The annual rainfall in the Dahanu Taluka cluster of Palghar District varied from 1457.7 mm in 2015 to 3570.3 mm in 2016, generating runoff ranging between 570.0 mm and 1958.4 mm over the 11-year period. The number of runoff events recorded each year ranged from 24 to 61, reflecting the frequency of rainfall episodes contributing to surface flow. Runoff as a percentage of total rainfall varied from 39.1% in 2015 to 54.9% in both 2016 and 2018, with an average runoff coefficient of 47.5% over the period. On average, 1233.0 mm of water was lost as surface runoff annually, representing approximately 47.5%

of the total rainfall of 2598.4 mm. Years with higher rainfall, such as 2016 and 2019, corresponded to higher runoff values of 1958.4 mm and 1683.9 mm, respectively, while years with lower rainfall, such as 2015, showed reduced runoff of 570.0 mm. The data demonstrates that nearly half of the monsoon precipitation contributes to surface runoff, indicating significant water movement across the watershed. The temporal distribution of runoff emphasizes its concentration during the peak monsoon months, highlighting the importance of managing this excess water for soil and water conservation within the cluster villages. The yearly and monthly variation in rainfall and runoff are depicted in Fig. 4.19 and 4.25.

Overall, the analysis demonstrates that runoff generation in the Dahan watershed is strongly governed by monsoon rainfall patterns, with the majority of runoff occurring during the peak monsoon months. Effective management of this runoff through suitable water harvesting and soil conservation measures can play a crucial role in improving water availability and supporting sustainable land and water resource management in the Dahanu Taluka cluster watershed.

Table 4.25. Relationship between rainfall and runoff

Year	Rainfall (mm)	Runoff (mm)	No. of Runoff Events	Runoff (%)
2014	2041.8	962.5	36	47.1
2015	1457.7	570.0	24	39.1
2016	3570.3	1958.4	61	54.9
2017	2851.0	1358.6	45	47.7
2018	2227.3	1222.5	34	54.9
2019	3174.3	1683.9	44	53.0
2020	2381.8	1034.4	36	43.4
2021	3081.1	1213.2	47	39.4
2022	2803.7	1373.5	51	49.0
2023	2251.6	1046.5	40	46.5
2024	2742.2	1139.7	53	41.6
Average	**2598.4**	**1233.0**	**43**	**47.5**

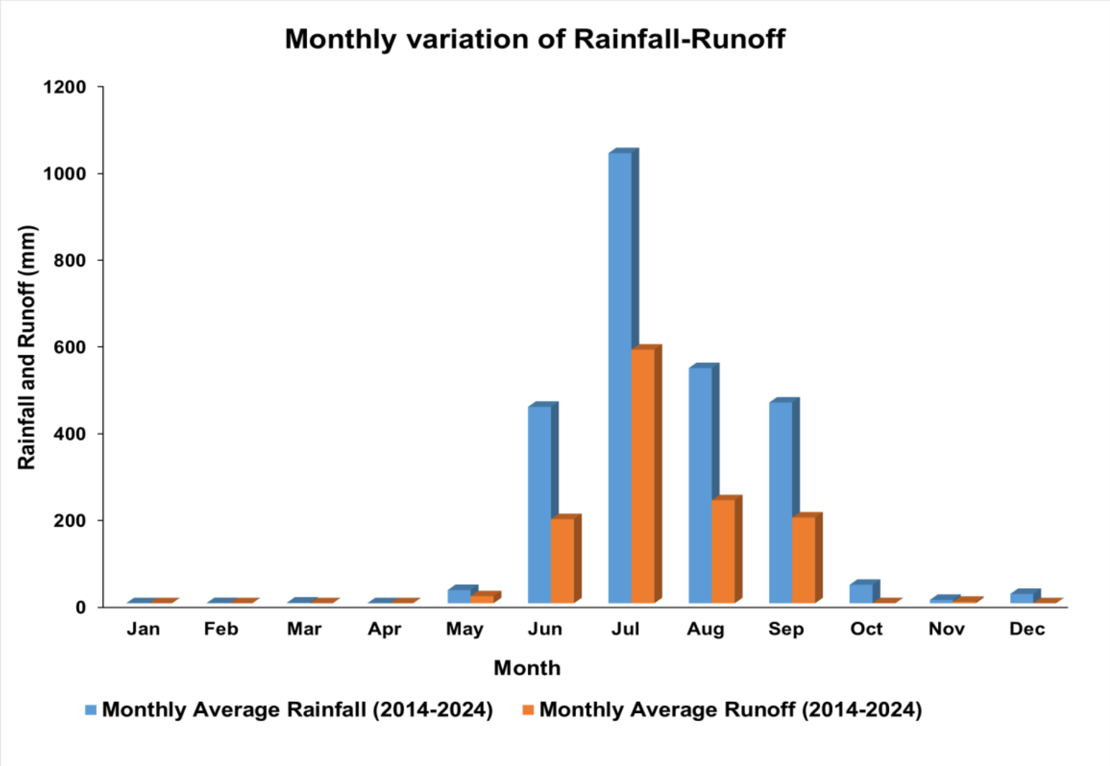


Fig 4.19: Monthly variation of rainfall-runoff in Dahanu watershed

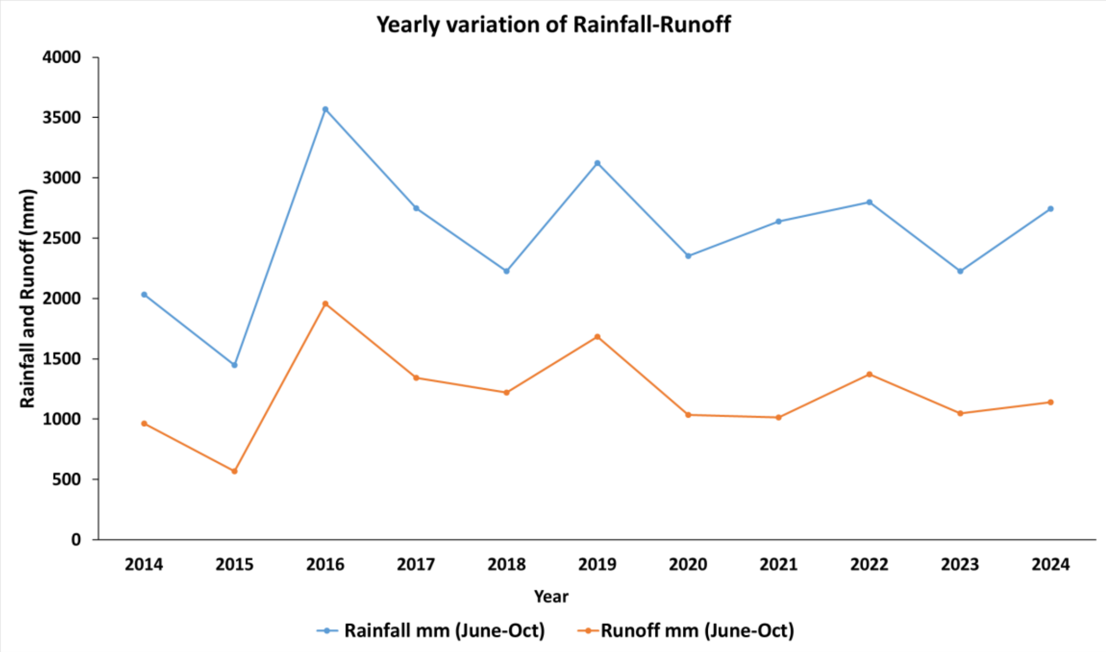


Fig 4.20: Yearly variation of rainfall-runoff in Dahanu watershed

4.7 Mapping of Groundwater Potential Zones

Groundwater is a crucial source of water for drinking, domestic use, and irrigation in

Dahanu Taluka. Although the region receives an average annual rainfall of 2598 mm, actual groundwater availability is uneven due to variations in recharge and the complex hydrogeology of the area. This spatial variability necessitates the mapping of groundwater potential zones for effective water resource management. A detailed Groundwater Potential Zonation (GWPZ) assessment was carried out for the cluster of 22 villages in Dahanu Taluka. The zonation was prepared using a multi-criteria spatial analysis that incorporated eight thematic layers: lithology, land use/land cover (LULC), drainage density, soil type, slope, elevation, landform, and rainfall distribution. Each layer contributes to determining the capacity of the area to support groundwater recharge and storage. The resulting GWPZ map classifies the watershed into five categories: Very Good, Good, Moderate, Poor, and Very Poor. According to the analysis (Fig. 4.21), 7.6% of the area falls under "Very Good," indicating optimal groundwater recharge conditions. "Good" potential zones account for 31.7%, representing areas with relatively high recharge potential. "Moderate" zones cover 24.1%, while "Poor" and "Very Poor" zones cover 17.1% and 19.6%, respectively, reflecting areas with limited infiltration due to steep slopes, rocky terrain, or less permeable soils. Overall, only 39.3% of the cluster has good to very good groundwater potential, while 60.7% exhibits moderate to very poor potential.

This zoning provides important spatial guidance for the design and implementation of watershed management interventions under project. It helps in planning groundwater recharge structures, soil and water conservation measures, and prioritizing areas that need urgent attention. The map also identifies zones where alternative water supply strategies may be required due to low groundwater potential. Given the hydrogeological complexity of the Konkan region, this integrated GWPZ assessment serves as an essential tool for sustainable groundwater management in Dahanu Taluka, supporting long-term water security for domestic, agricultural, and ecological needs across the 22 villages.

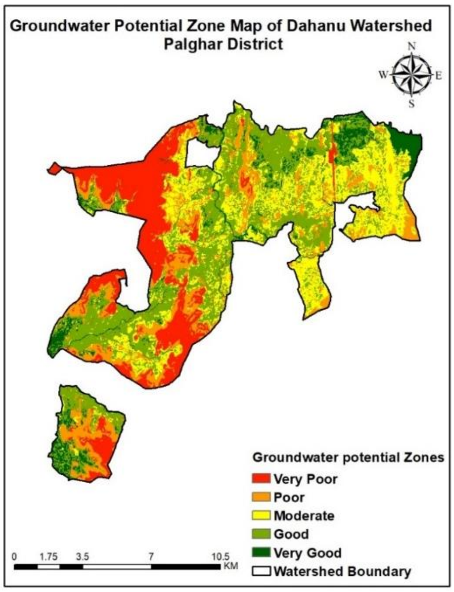


Fig. 4.21. Ground water potential zones in Dahanu watershed

4.8 Evaluation of Soil-Site Suitability for Crops

Crop growth primarily depends on soil and climate. Evaluating soil-site suitability for crops requires a careful assessment of key soil attributes including soil depth, texture, fertility status, and drainage conditions. This is important because a soil's physicochemical properties and the crop's micro-environment directly influence the availability of water and essential nutrients. The evaluation process helps in the interpretation of soil maps to assess their suitability for various field and horticultural crops, thereby supporting the development of scientific land-use plans for watershed management.

The suitability of soils for crop cultivation was assessed using the criteria proposed by Naidu et al. (2006), employing a hierarchical land evaluation classification system based on land utilization types with a structure of orders, classes, subclasses, and units. This system recognizes two primary orders: Suitable (S), subdivided into three classes S1 (High suitability), S2 (Moderate suitability), and S3 (Marginal suitability) and Not Suitable (N),

Soil-site suitability was evaluated by assessing limitations across five key categories: climate (c), topography (t), wetness (w), soil fertility (f), and physical soil constraints (s) using a grading scale from 0 to 4, where Grade 0 signifies no limitation and optimal conditions; Grade 1 denotes a slight, nearly optimal limitation; Grade 2 indicates a moderate limitation with noticeable negative effects on crop performance; Grade 3 represents a severe limitation making the land uneconomical; and Grade 4 signifies a very severe limitation where crop yields are below economically viable levels, rendering the land unsuitable for the proposed agricultural use.

To assess the suitability of the land for agricultural crops and other uses, an evaluation was conducted considering a range of soil-site parameters grouped into several key categories: climatic variables (rainfall and temperature), topographic features (slope, landscape position, and susceptibility to erosion), wetness conditions (drainage, risk of flooding, and soil aeration), physical soil properties (texture, soil depth, structure, and available soil moisture), fertility attributes (soil pH, nutrient availability, organic matter content and cation exchange capacity). By integrating these multiple parameters, the watershed area was evaluated to determine its suitability for crops that are either commonly cultivated or possess the potential for introduction.

4.8.1 Soil-Site Suitability for Rice Cultivation

The soil site suitability assessment for rice shows that the majority of the cluster is classified as Marginally Suitable (S3), covering 11,312.3 ha (82.3%). Also, moderately suitable (S2) land accounts for 1,903.4 ha (13.8%). The Palghar cluster has favorable climate and soils for the cultivation of rice, but steep slopes affect the cultivation of rice. Terracing would help in good cultivation of rice (Table 4.26, Fig. 4.22)

Table 4.26 Area under suitability sub-classes for Rice cultivation

Sr. No.	Suitability class	Area (ha)	Percent (%)
1	Moderately Suitable (S2)	1903.44	13.84
2	Marginally Suitable (S3)	11312.32	82.25
3	Habitation/Built up	156.90	1.14
4	Waterbody	380.46	2.77
	Total	**13753.12**	**100.00**

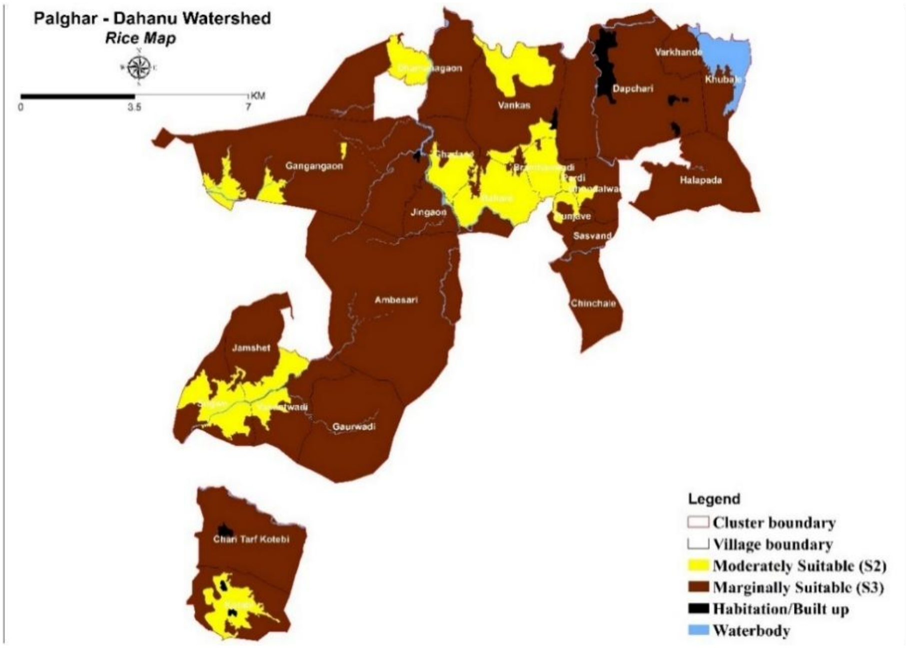


Fig. 4.22 Soil site suitability map for Rice cultivation

4.8.6 Soil-Site Suitability for Black gram Cultivation

The soil site suitability assessment identifies that Moderately Suitable (S2) area for black gram cultivation is 7185.2 ha (52.2%), representing the largest portion of the cluster as depicted in Fig. 4.23 and Table 4.27. Marginally Suitable (S3) regions cover 6030.6 ha (43.8%). While steep slopes in the Palghar cluster limit the overall suitability for black gram cultivation, the presence of adequate rainfall and well-drained soils supports its growth. This topographical limitation could be mitigated through the implementation of terracing.

Table 4.27 Area under suitability sub-classes for Black gram cultivation

Sr. No.	Suitability class	Area (ha)	Percent (%)
1	Moderately Suitable (S2)	7185.2	52.2
2	Marginally Suitable (S3)	6030.6	43.8
3	Habitation/Built up	156.9	1.1
4	Waterbody	380.5	2.8
5	**Total**	**13753.1**	**100.0**

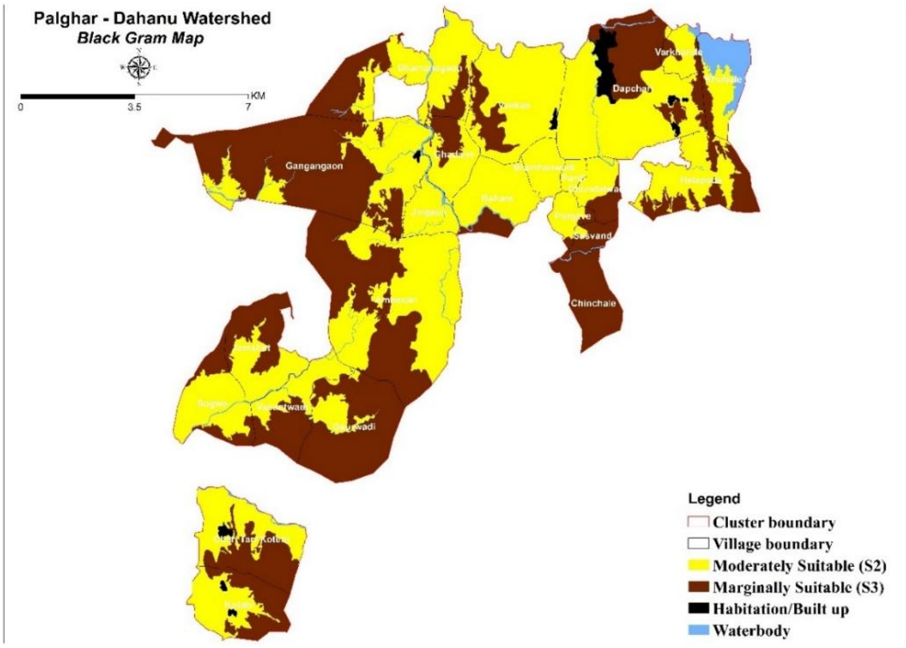


Fig. 4.23 Soil site suitability map for Black gram cultivation

4.8.5 Soil-Site Suitability for Jackfruit Cultivation

The soil site suitability analysis for Jackfruit cultivation reveals that over half of the region is classified as Not Suitable (N), covering 7,092.7 ha (51.6%). Furthermore, the land categorized as Marginally Suitable (S3) accounts for 5,084.6 ha (37.0%), while the area designated as Moderately Suitable (S2) represents 1,038.4 ha (7.6%). The Palghar cluster has adequate rainfall and well-drained soil but shallow soils, reducing the overall suitability for Jackfruit cultivation.

Table 4.28 Area under suitability sub-classes for Jackfruit cultivation

Sr. No.	Suitability class	Area (ha)	Percent (%)
1	Moderately Suitable (S2)	1038.4	7.6
2	Marginally Suitable (S3)	5084.6	37.0
3	Not Suitable (N)	7092.7	51.6
4	Habitation/Built up	156.9	1.1
5	Waterbody	380.5	2.8
	Total	**13753.1**	**100.0**

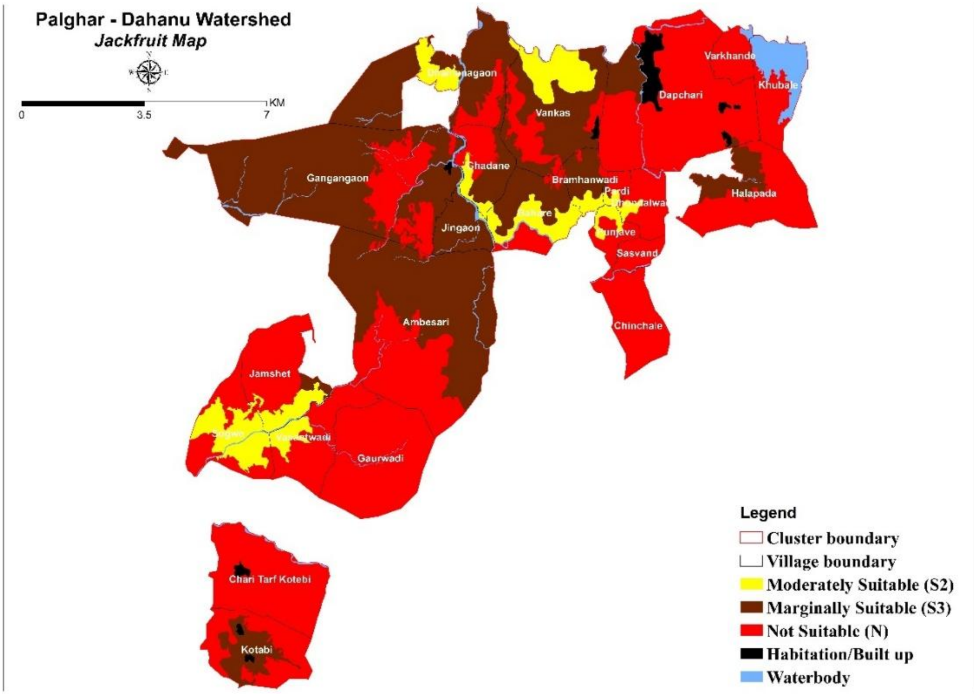


Fig. 4.24 Soil site suitability map for Jackfruit cultivation

4.8.7 Soil-Site Suitability for Coconut Cultivation

Based on the soil site suitability analysis for Coconut, the largest portion of the area is classified as marginally Suitable (S3), covering 4,960.9 ha (36.1%) as shown in Table 4.29 and Fig. 4.25. This is followed by moderately Suitable (S2) land at 4,307.0 ha (31.3%) and not Suitable (N) land spanning 3,912.3 ha (28.4%). A small fraction of the landscape is designated as Highly Suitable (S1), representing 35.6 ha (0.3%). The cluster has adequate rainfall and soil for good cultivation of Coconut.

Table 4.29 Area under suitability sub-classes for Coconut cultivation

Sr. No.	Suitability class	Area (ha)	Percent (%)
1	Highly Suitable (S1)	35.6	0.3
2	Moderately Suitable (S2)	4307.0	31.3
3	Marginally Suitable (S3)	4960.9	36.1
4	Not Suitable (N)	3912.3	28.4
5	Habitation	156.9	1.1
6	Waterbody	380.5	2.8
	Total	**13753.1**	**100.0**

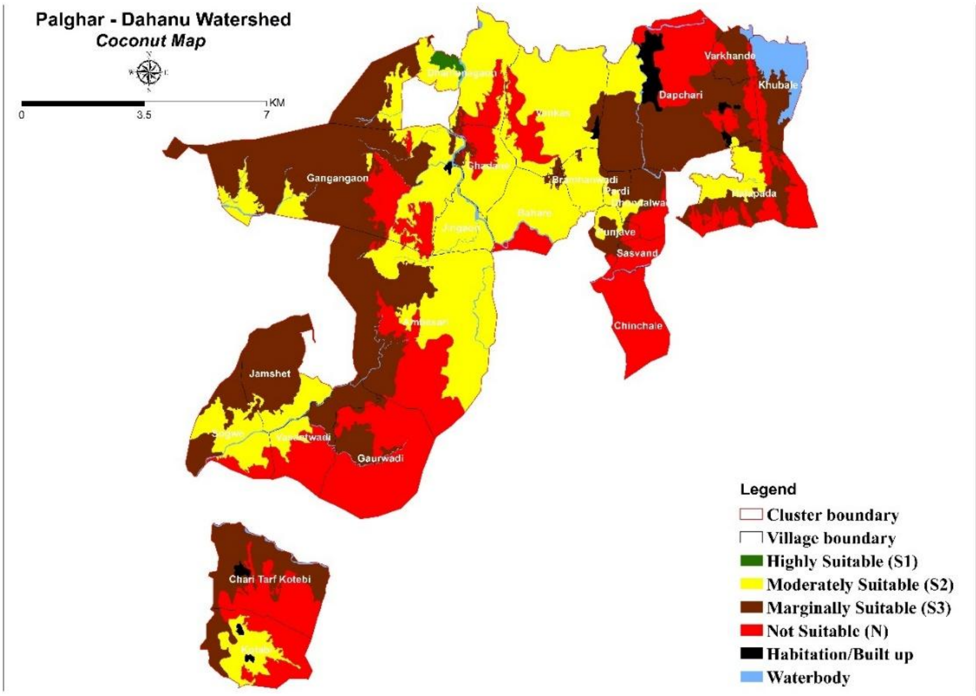


Fig. 4.25 Soil site suitability map for Coconut cultivation

4.8.8 Soil-Site Suitability for Sapota Cultivation

Based on the soil site suitability analysis for sapota, the largest portion of the area is classified as Marginally Suitable (S3), covering 6,042.9 ha (43.9%) as shown in Fig 4.26 and Table 4.30. This is followed by Not Suitable (N) land at 3,912.3 ha (28.4%) and Moderately Suitable (S2) land spanning 3,260.6 ha (23.7%). this cluster has favorable climate and well-drained soil but steep slopes reduce the overall suitability for sapota cultivation

Table 4.30 Area under suitability sub-classes for Sapota cultivation

Sr. No.	Suitability class	Area (ha)	Percent (%)
1	Moderately Suitable (S2)	3260.6	23.7
2	Marginally Suitable (S3)	6042.9	43.9
3	Not Suitable (N)	3912.3	28.4
4	Habitation	156.9	1.1
5	Waterbody	380.5	2.8
	Total	**13753.1**	**100.0**

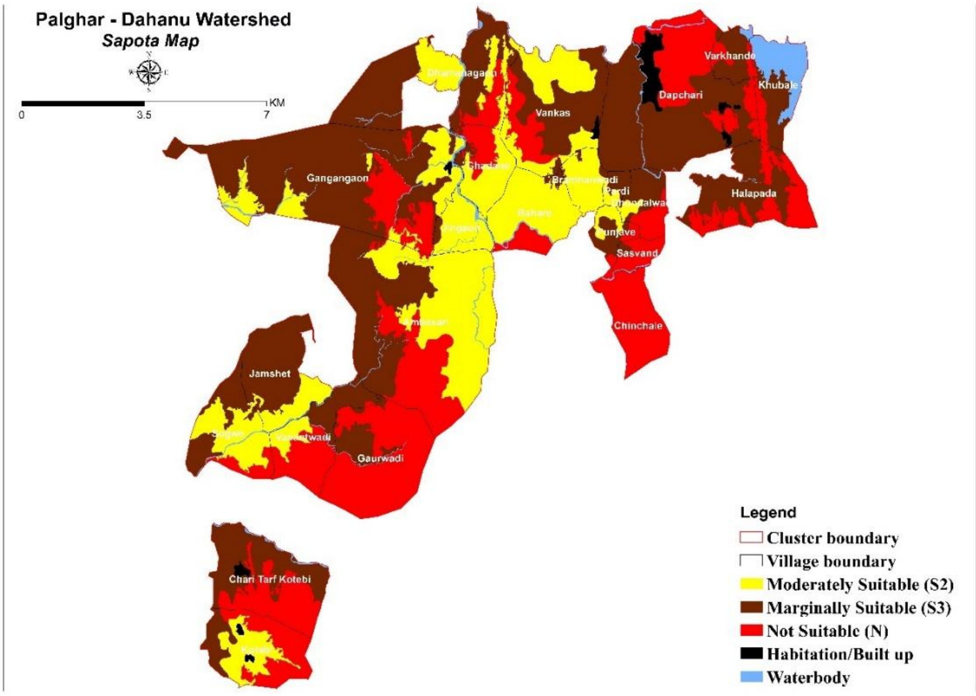


Fig. 4.26 Soil site suitability map for Sapota cultivation

4.8.9 Soil-Site Suitability for Banana Cultivation

Based on the soil site suitability analysis for banana cultivation, the largest portion of the area is classified as marginally Suitable (S3), covering 6,243.26 ha (45.40%) as depicted in Fig. 4.27 and Table 4.31. This is followed by not Suitable (N) land at 3,912.26 ha (28.45%) and moderately suitable (S2) land spanning 3,060.24 ha (22.25%). The Palghar cluster has well-drained soil with a favorable climate and adequate rainfall, making it suitable for banana cultivation.

Table 4.31 Area under suitability sub-classes for Banana cultivation

Sr. No.	Suitability class	Area (ha)	Percent (%)
1	Moderately Suitable (S2)	3060.24	22.2
2	Marginally Suitable (S3)	6243.26	45.4
3	Not Suitable (N)	3912.26	28.4
4	Habitation/Built up	156.90	1.14
5	Waterbody	380.46	2.77
	Total	**13753.12**	**100.00**

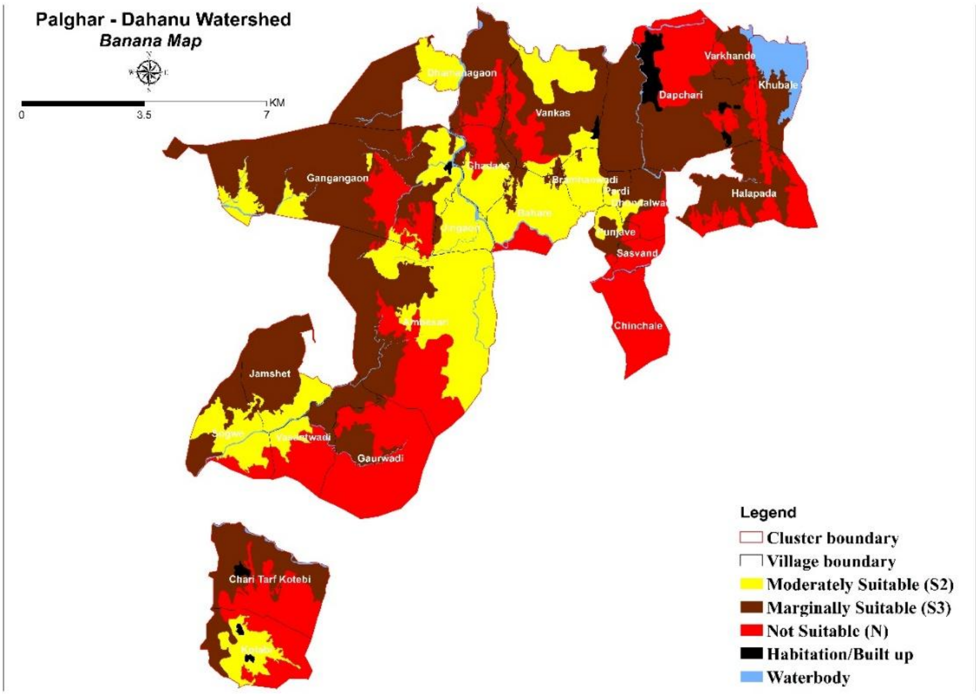


Fig. 4.27 Soil site suitability map for Banana cultivation

4.8.10 Soil-Site Suitability for Chilli Cultivation

According to the soil site suitability assessment for Chilli , Moderately Suitable (S2) land spans 6420.4 ha (46.7%), providing a substantial foundation for production with moderate input requirements. Also, Marginally Suitable (S3) region occupies 6795.4 ha (49.4%), representing the largest single classification. The Palghar cluster has well drained soils but the steep slopes in the region reduce the overall suitability for Chilli cultivation. (Table 4.32, Fig. 4.31)

Table 4.32 Area under suitability sub-classes for Chilli cultivation

Sr. No.	Suitability class	Area (ha)	Percent (%)
1	Moderately Suitable (S2)	6420.4	46.7
2	Marginally Suitable (S3)	6795.4	49.4
3	Habitation/Built up	156.9	1.1
4	Waterbody	380.5	2.8
	Total	**13753.1**	**100.0**

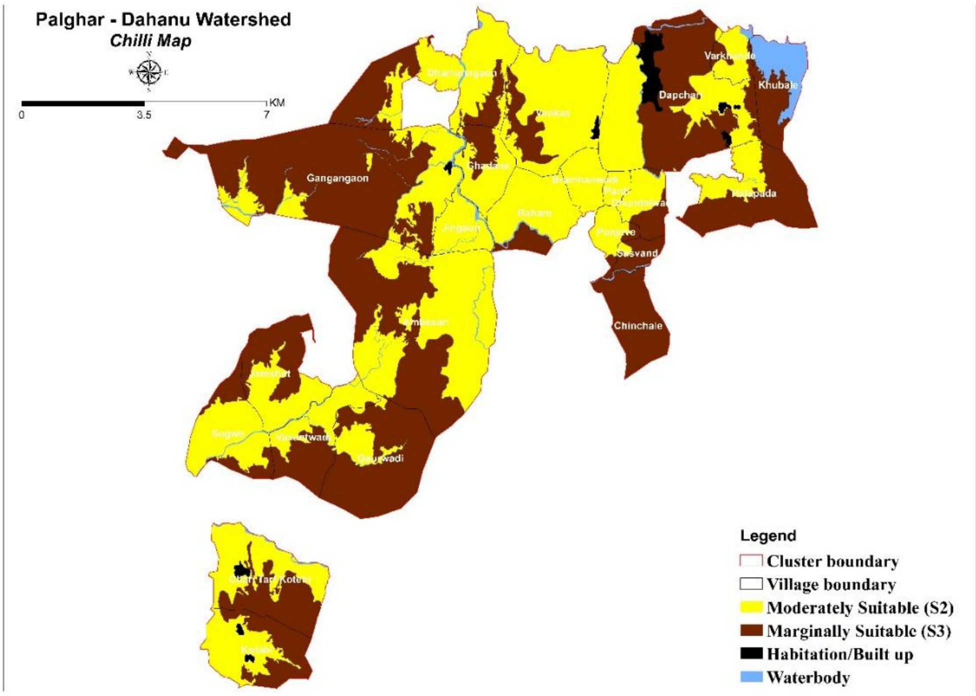


Fig. 4.28 Soil site suitability map for Chilli cultivation

4.8.11 Soil-Site Suitability for Brinjal Cultivation

According to the soil site suitability assessment for brinjal, Moderately Suitable (S2) land encompasses 6377.8 ha (46.4%), representing regions where sustainable cultivation is feasible with standard management adjustments. Furthermore, Marginally Suitable (S3) tracts account for 6838.0 ha (49.7%), indicating the dominant land class and signaling a requirement for more intensive soil conservation practices to overcome inherent site limitations. The Palghar cluster has well drained soils but the steep slopes reduce the overall suitability for brinjal cultivation (Table 4.33 Fig. 4.33)

Table 4.33 Area under suitability sub-classes for Brinjal cultivation

Sr. No.	Suitability class	Area (ha)	Percent (%)
1	Moderately Suitable (S2)	6377.8	46.4
2	Marginally Suitable (S3)	6838.0	49.7
3	Habitation/Built up	156.9	1.1
4	Waterbody	380.5	2.8
	Total	**13753.1**	**100.0**

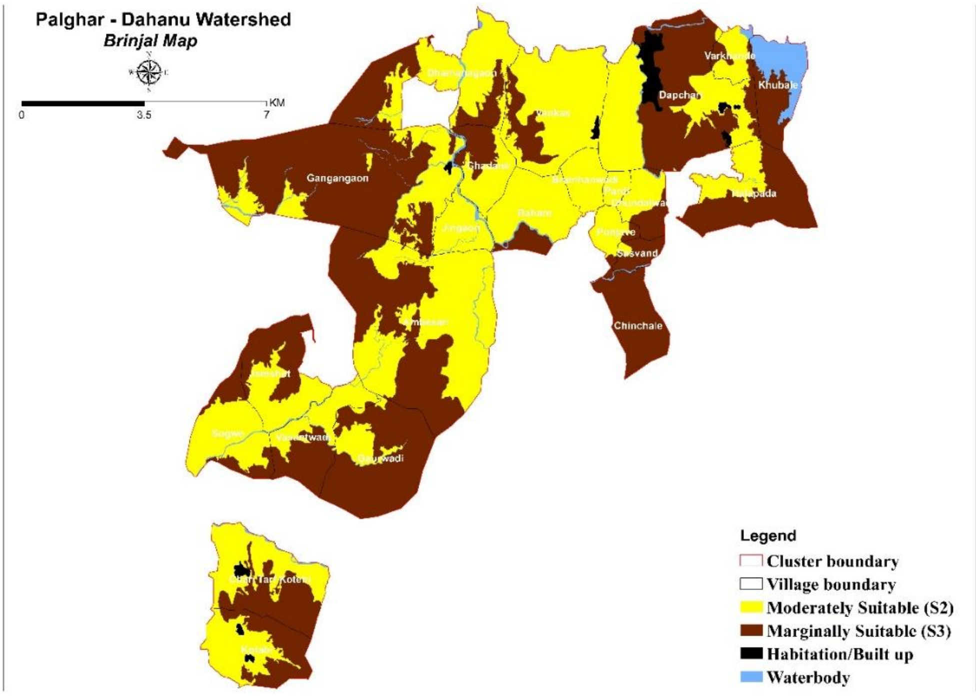


Fig. 4.29 Soil site suitability map for Brinjal cultivation

4.8.12 Soil-Site Suitability for Tomato Cultivation

Under the soil site suitability assessment for tomato, Moderately Suitable (S2) land cover 6377.8 ha (46.4%), indicating areas where sustainable production is achievable through moderate management adjustments. Conversely, Marginally Suitable (S3) land encompasses 6838.0 ha (49.7%), marking it as the dominant classification. The Palghar cluster has steep slopes which reduces the overall suitability for cultivation.

Table 4.34 Area under suitability sub-classes for Tomato cultivation

Sr. No.	Suitability class	Area (ha)	Percent (%)
1	Moderately Suitable (S2)	6377.8	46.4
2	Marginally Suitable (S3)	6838.0	49.7
3	Habitation/Built up	156.9	1.1
4	Waterbody	380.5	2.8
	Total	**13753.1**	**100.0**

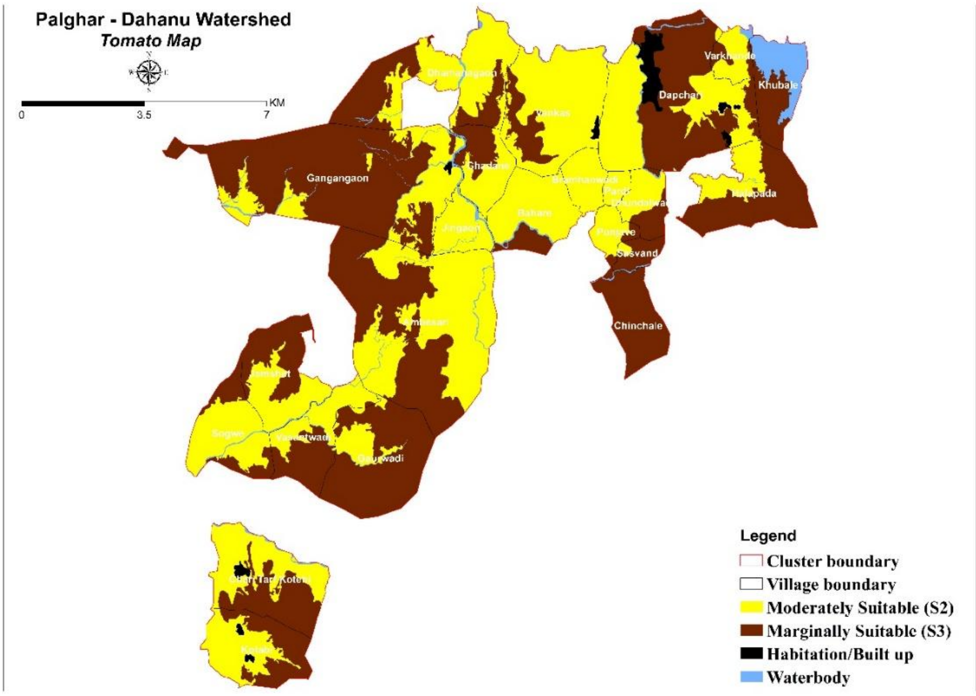


Fig. 4.30 Soil site suitability map for Tomato cultivation

4.9 Morphometric Analysis Dahanu Cluster, Palghar

In this study, runoff estimation, groundwater potential zone (GWPZ) mapping, and soil and water conservation (SWC) planning were carried out at the village cluster level to enable site-specific assessment and practical implementation. In contrast, morphometric analysis was carried out at the watershed level, as morphometric parameters are governed by natural drainage boundaries rather than administrative limits. Morphometric analysis involves the quantitative assessment of drainage network characteristics, basin geometry, slope, and relief, all of which directly influence runoff generation, soil erosion, and groundwater recharge. These parameters are derived from a hydrologically closed unit defined by natural divides. A watershed represents such a unit, where streams develop in a hierarchical order and converge toward a common outlet, enabling accurate computation of indices such as drainage density, bifurcation ratio, stream frequency, form factor, and relief ratio.

Village clusters, being administrative units, do not correspond to complete drainage systems. Streams frequently traverse village boundaries; therefore, conducting morphometric analysis at the cluster level would produce truncated stream networks and distorted basin geometry, leading to unreliable hydrological interpretation. Consequently, morphometric analysis was intentionally performed at the watershed level to maintain hydrological accuracy, while runoff estimation, GWPZ mapping, and SWC planning were carried out at the village-cluster level for effective local implementation. This integrated framework links natural hydrological processes with decentralized planning for sustainable water resource management. The Dahanu cluster in Palghar district, Maharashtra, comprises 23 villages, which form the study cluster containing three sub-watersheds (Fig. 4.31). Sub-watershed-wise area, stream order, elevation range, and drainage network characteristics are given in Table 4.35 and Fig. 4.32.

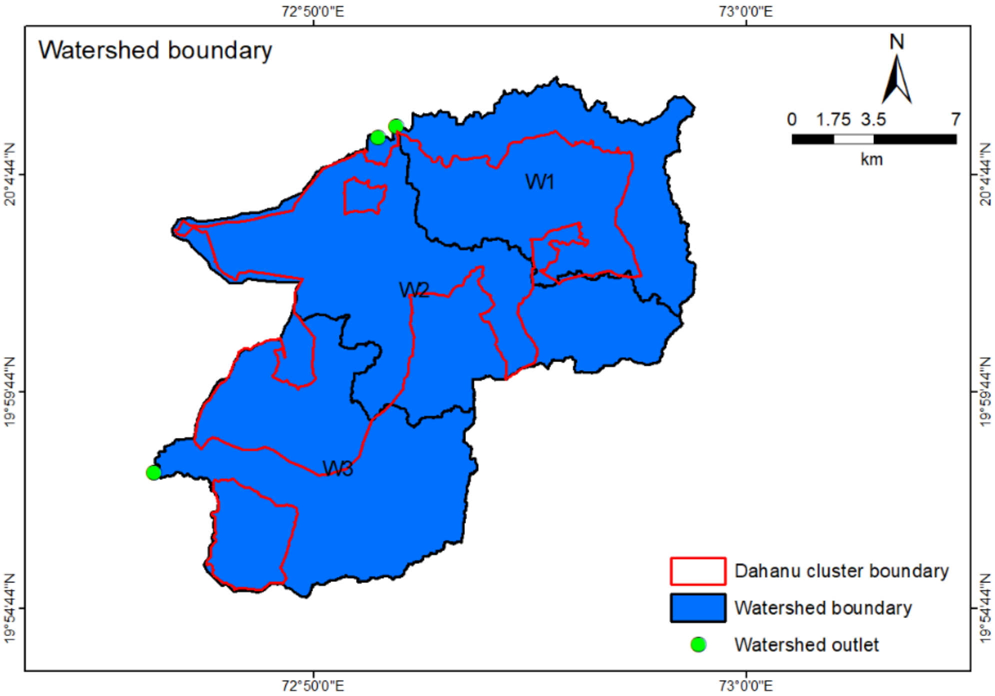
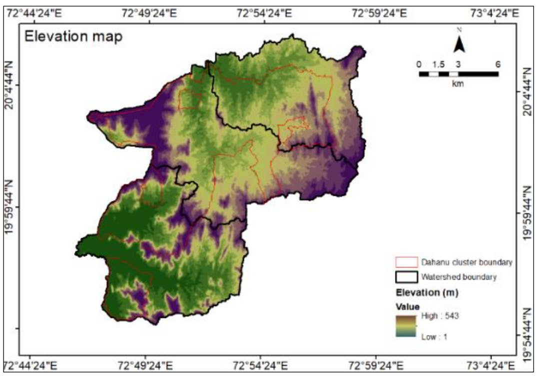
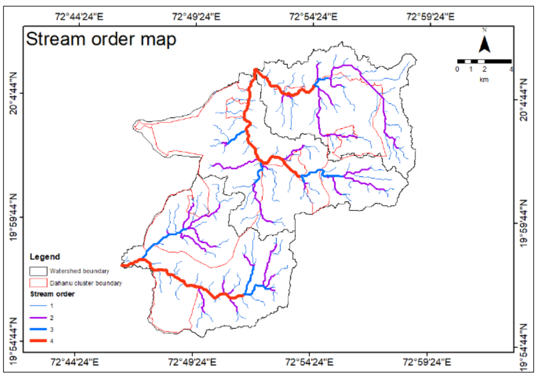


Fig. 4.31: Map of Dahanu cluster depicted through sub-watershed

Table 4.35: Distribution of area under different sub-watershed, Dahanu

Sr. No.	Sub-watershed name	Sub-watershed order	Elevation (m)	Area (km^2)	Flow origination
1	W1	4^{th}	28-436	74.68	North-west
2	W2	4^{th}	28-543	103.14	North-west
3	W3	4^{th}	1-430	95	South-west
			Total	**272.82**	





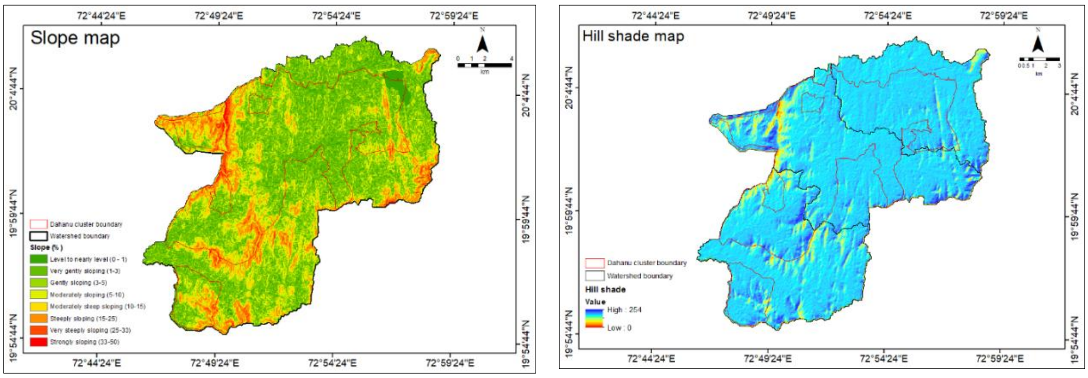


Fig. 4.32: Elevation, stream network, slope and hill shade map of sub-watershed

Linear aspect

Linear morphometric parameters focus on the stream network characteristics and its influence on runoff and watershed behaviour. The morphometric analysis of the three sub-watersheds shows clear variation in drainage characteristics. W2 has the highest number of streams (110) and total stream length (101.4 km), indicating a well-developed drainage network, while W1 has the lowest values. The bifurcation ratio ranges from 5.6 (W2) to 5.5 (W3), suggesting relatively greater structural influence in W2. Mean channel length and valley length are highest in W2, reflecting more mature channel development, whereas W3 records the lowest values. Channel index is highest in W1, and W3 (1.5), indicating greater sinuosity. Basin perimeter is also largest in W2 (84.49 km), confirming it as the most extensive sub-watershed, while W1 and W3 is the smallest.

Table 4.36: Linear morphometric parameters of sub-watersheds, Dahanu cluster, Palghar

Sr.no.	Morphometric parameter	Symbol	Unit	W1	W2	W3
1	No. of streams	Nu	No	92	110	105
2	Stream length	Lu	km	82.9	101.4	101.3
3	Bi-furcation ratio	Rb	-	5.1	5.6	5.5
4	Mean channel length	Cl	km	19.54	20.46	17.88
5	Valley Length	Vl	km	16.54	17.8	15.43
6	Channel Index	Ci	-	1.5	1.4	1.5
7	Minimum areal distance	Adm	km	12.89	14.68	12.22
8	Valley Index	Vi	-	1.28	1.21	1.26
9	Basin perimeter	P	km	65.1	84.49	65.46

Areal Aspects

Areal parameters describe the two-dimensional properties of the watershed, including shape, size, and drainage efficiency, which directly influence runoff and groundwater recharge. The analysis reveals variation in basin shape and drainage characteristics among the three sub-watersheds. Basin area is highest in W2 (103.14 km²) and lowest in W1 (74.68 km²). Mean basin width is also greater in W3 (5.78 km). Form factor (Ff) and elongation ratio (Re) are highest in W3 (0.35 and 0.20), suggesting a comparatively more circular basin, whereas W1 show lower values, indicating elongated shapes. Circularity ratio (Rc) is maximum in W3 (0.28), while compactness coefficient (Cc) is highest in W2 (2.36), reflecting greater basin irregularity. Standard sinuosity index (Ssi) ranges from 1.15 (W2) to 1.18 (W1), indicating relatively higher channel sinuosity in W2. Drainage parameters show that stream frequency (Fs) is highest in W3 (1.33 per km²) and lowest in W1, W2 (1.27 per km²). Drainage density (Dd) is nearly similar in W1 and W3 (1.1 km/km²) but lower in W2 (1.0 km/km²). Drainage intensity (Di) follows a similar trend, with the highest value in W2 (1.29). Length of overland flow (Lg) is greatest in W2 (0.51 km) and lowest in W1 (0.45 km), indicating shorter runoff travel distance in W2.

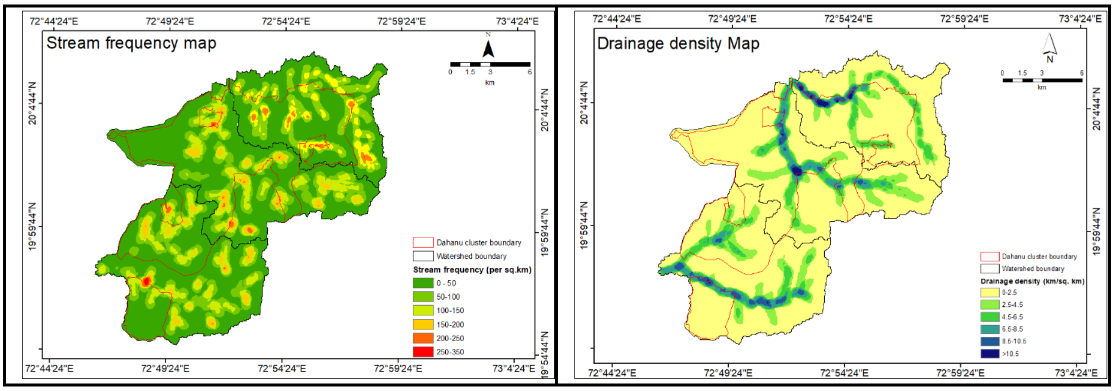


Fig. 4.33: Steam frequency and drainage density map of sub-watershed

Table 4.37: Areal morphometric parameters of sub-watersheds, Dahanu cluster, Palghar

S. No	Parameter	Symbol	Method/Formula	Unit	W1	W2	W3
1.	Mean basin width	Wb	Wb=A/Lb	km	4.4	5.69	5.78
2.	Basin area	A	GIS Analysis	km^2	74.68	103.14	95
3.	Relative perimeter	Pr	Pr= A/P	km	1.15	1.22	1.45
4.	Length area relation	Lar	Lar = 1.4*A0.6	km^2	18.62	22.60	21.52
5.	Lemniscate's	k	K = Lb2/A	-	3.9	3.2	2.8
6.	Form factor	Ff	Ff = A/Lb2	-	0.26	0.31	0.35
7.	Elongation ratio	Re	Re = 2/Lb*(A/π)0.5	-	0.20	0.10	0.20
8.	Circularity ratio	Rc	Rc = 12.57*(A/P2)	-	0.22	0.18	0.28
9.	Compactness coefficient	Cc	Cc = 0.2841*P/A0.5	-	2.14	2.36	1.91
10.	Standard sinuosity index	Ssi	Ssi = Ci/Vi	-	1.18	1.15	1.16
11.	Stream frequency	Fs	Fs = Nu/A	Per km^2	1.27	1.27	1.33
12.	Drainage Density	Dd	Dd = Lu/A	km/km^2	1.1	1.0	1.1
13.	Drainage Intensity	Di	Di = Fs/Dd	-	1.15	1.29	1.24

14.	Length of Overland Flow	Lg	Lg = A/2*Lu	km	0.45	0.51	0.47

Relief Aspects

The maximum basin height (Z) is highest in W2 (543 m) and lowest in W3 (430 m), while total basin relief (H) is also maximum in W2 (515 m) and minimum in W1 (408 m). Relief ratio (Rhl) is highest in W2 (28.4), indicating steeper terrain conditions, whereas W1 shows the lowest value (23.9). Relative relief ratio (Rhp) is greatest in W3 (655.4), followed by W1 and W2, suggesting higher relief intensity in W3. The ruggedness number (Rn) is maximum in W2 (0.51), reflecting more dissected and erosion-prone terrain, while W3 has the lowest value (0.46). Similarly, the Melton ruggedness number (MRn) is highest in W2 (50.7), indicating comparatively higher susceptibility to runoff and erosion processes. The slope distribution across the three watersheds (W1, W2 and W3) indicates that the terrain is very gently sloping (1-3%) and gently sloping (3-5%) in all areas. In W1 to W3, nearly 39.3%, 29.8% and 25.8% of the total area fall under the very gently sloping class, respectively, followed by gently sloping lands. W3 shows a comparatively higher proportion of moderately sloping land (5-10%) at 20.2%, indicating relatively undulating terrain. In W3, moderately steep sloping dominates as (11.6 %), while steeply sloping classes occupy only a 12.7 % in watersheds.

Table 4.38: Relief morphometric parameters of sub-watersheds, Dahanu cluster, Palghar

Sr. no.	Parameters	Symbol	Methods/Formula	W1	W2	W3
1.	Height of at basin mouth	z	DEM	28	28	1
2.	Maximum height of the basin	Z	DEM	436	543	430
3.	Total basin relief	H	H = Z - z	408	515	429
4.	Relief ratio	Rhl	Rhl = H / Lb	23.9	28.4	26.1
5.	Relative relief ratio	Rhp	Rhp = H * 100 / P	626.7	609.5	655.4
6.	Ruggedness number	Rn	Rn = Dd*(H/1000)	0.45	0.51	0.46
7.	Melton Ruggedness number	MRn	MRn = H / A^0.5	47.2	50.7	44.0

Implications for Soil and Water Conservation

The morphometric characteristics of the three sub-watersheds indicate the need for different soil and water conservation measures. Sub-watershed W2, which has the highest number of streams, longest stream length, greater basin relief, and higher ruggedness number, is more prone to rapid runoff and soil erosion. Therefore, structural measures such as check dams, gully plugs, gabion structures, contour bunding, and terracing should be adopted to reduce runoff velocity and control erosion. Sub-watershed W1, characterized by lower relief, smaller basin area, and relatively elongated basin shape, has moderate runoff potential and better infiltration conditions; hence, moisture conservation and water harvesting practices such as contour farming, graded bunds, farm ponds, and vegetative barriers are more suitable. Sub-watershed W3 shows higher stream frequency, greater circularity ratio, and a relatively higher proportion of moderately sloping land, indicating quicker runoff concentration and localized erosion risk. In this watershed, measures such as contour trenches, vegetative hedges, strip cropping, and small check dams along drainage lines are recommended. Overall, since very gently sloping and gently sloping lands dominate the area, a combination of structural, vegetative, and agronomic practices would effectively reduce soil erosion, regulate runoff, and enhance groundwater recharge in the watershed.

4.10 Soil and Water Conservation Measures

A soil and water conservation (SWC) plan has been prepared for the Dahanu cluster watershed based on the land resource inventory (LRI) and analysis of landform, soil characteristics, slope, drainage, land use/land cover, etc. The watershed is characterized by diverse physiographic units such as foothills, hills and ridges, pediments, isolated mounds. Each of these landforms exhibits different soil textures ranging from clay, loam, silty clay, clay loam, to silty clay loam, with depths varying from very shallow (<25 cm) to very deep (>150 cm). The slopes range from gentle (0–3%) to very steep (>20%), and the LULC categories include cultivable land, forest, degraded forest, plantation, trees, open scrub, wasteland, canal, and built-up. These combinations directly influence runoff generation, infiltration capacity, and groundwater recharge potential, and therefore form the basis for site-specific soil and water conservation measures. The proposed interventions have been spatially allocated considering site suitability and existing land use conditions to ensure effective and sustainable watershed management. The types and distribution of the proposed measures within the watershed are summarized in Table 4.39 and illustrated in Fig. 4.34.

In cultivable land located in foothills with shallow soils and slopes between 5-15%, the recommended interventions include field bunds, contour bunds, conservation bench terraces, and strengthening of bunds with safe runoff disposal. These measures help reduce soil erosion, retain moisture, and improve crop productivity. In pediment areas with moderate to deep soils and gentle slopes (0–10%), farm ponds, and field bunds are proposed, along with conservation bench terraces in unbunded fields and paddy fields and area having slope >10% with greater soil depth Bench terrace is recommended. These structures enhance water retention, promote infiltration, and provide supplemental irrigation. For forest and degraded forest areas across foothills, hills, and pediments, silt detention trenches in downstream locations are recommended to trap sediments and reduce siltation in water bodies. Afforestation and contour trenches are also proposed to stabilize slopes, improve vegetation cover, and increase infiltration. In plantation, trees, openscrub, and wasteland areas with gentle to moderate slopes (0–10%), in-situ moisture conservation measures are emphasized to retain soil moisture. Afforestation and horticultural plantations are suggested for wastelands, while farm ponds are proposed in plantation zones to provide water for irrigation and improve vegetation growth.

In canal and seasonal stream courses, structural measures such as cement nala bunds and earthen nala bunds are proposed, along with repairing of existing structures and desilting of nallas. These interventions help regulate streamflow, store water, and reduce erosion along stream banks. Built-up areas, on the other hand, do not require specific soil and water conservation measures, but runoff management through proper drainage planning is necessary to prevent flooding and waterlogging. This plan ensures sustainable land use, reduces soil erosion, enhances groundwater recharge, and improves water availability for agriculture and vegetation in Dahanu block. By implementing these measures, the watershed can achieve long-term sustainability, ecological balance, and improved livelihoods for the local communities dependent on its resources.

Table 4.39 Proposed soil and water conservation (SWC) plan for Dahanu watershed

Sr. No.	Proposed SWC Plan
1	Silt Detention Trench in Downstream
2	Field bund/Contour Bund/Strengthening of existing bund with safe disposal of runoff water, Farm pond
3	Conservation Bench Terrace in Unbunded Field/Field bund in Paddy Field/Strengthening of existing bund with safe disposal of runoff water
4	Field bund/Contour Bund/Strengthening of existing bund with safe disposal of runoff water
5	In-situ Moisture Conservation Measures
6	Built-up
7	In-situ Moisture Conservation Measures, Farm pond
8	Afforestation, Contour Trench, Silt Detention Trench in Downstream
9	Reservoir
10	Stream Bank Plantation
11	Afforestation, In-situ Moisture Conservation Measures
12	Road
13	Field bund/Strengthening of existing bund with safe disposal of runoff water
14	Horticultural Plantation, In-situ Moisture Conservation Measures, Farm pond
15	Horticultural Plantation, In-situ Moisture Conservation Measures
16	Bench Terrace
17	Miscellaneous
18	Cement Nala Bund, Earthen Nala Bund / Repairing of Cement Nala Bund and Desilting of Nallas
19	Renovation of Waterbody as per the site condition
20	Afforestation, In-situ Moisture Conservation Measures, Farm pond

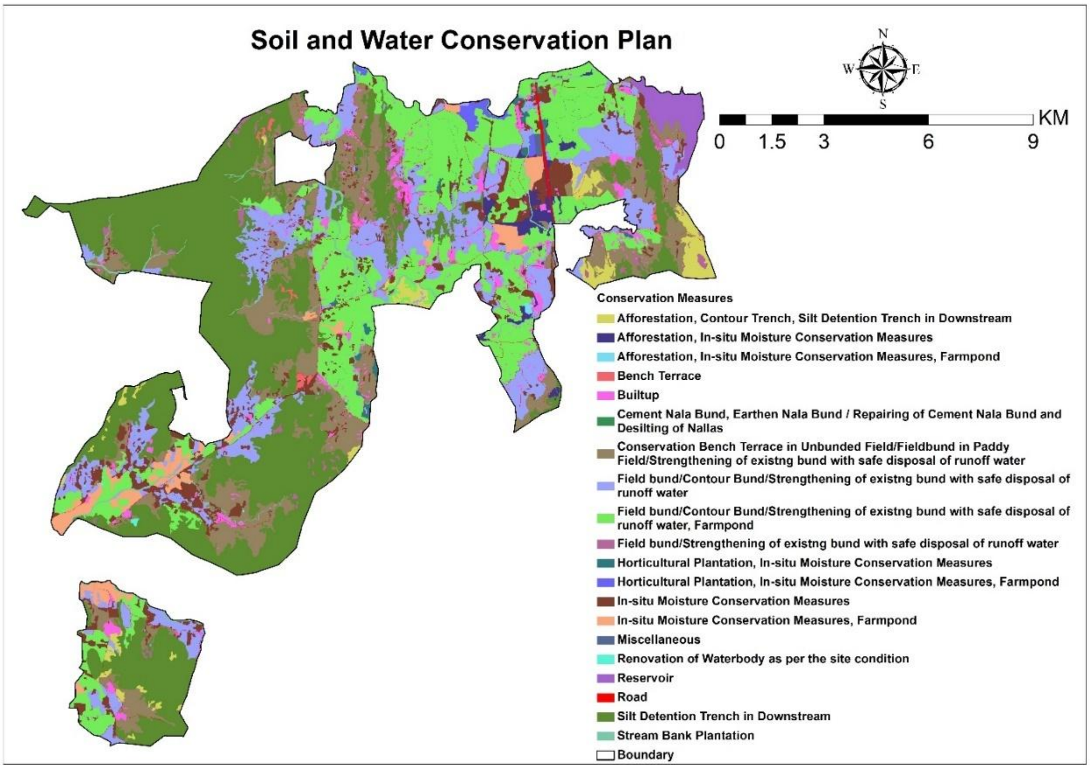


Fig. 4.34: Soil and water conservation measures proposed for Dahanu watershed

CHAPTER 5

SUMMARY AND CONCLUSION

5.1 SUMMARY

- The Dahanu cluster watershed is located in Dahanu Taluka of Palghar district, Maharashtra, and represents a predominantly rural landscape where agriculture forms the principal livelihood, supported by forest patches and horticultural plantations. The Varoli River is the major river flowing through the watershed and serves as an important source of water for irrigation, domestic use, and other local activities.
- The watershed experiences a humid tropical monsoon climate typical of the Konkan coastal region, receiving an average annual rainfall of about 2598 mm, most of which occurs between June and September under the influence of the southwest monsoon. Despite high rainfall, the strong seasonal concentration leads to significant surface runoff and limited water availability during the post-monsoon period.
- Geologically, the watershed is mainly underlain by Deccan Trap basalt, while geomorphologically the landscape consists of pediments, pediplains, hills and ridges, foothills, valleys, plateau tops, and isolated mounds, with highest elevation up to 543 m above mean sea level. Pediments occupy the largest area followed by hills and ridges, indicating a moderately dissected terrain.
- The slope within the watershed ranges from nearly level to extremely steep gradients, with moderately sloping lands (8–15%) occupying the largest area (38.14%), followed by moderately steep slopes (15–30%). These slope conditions significantly influence runoff generation, soil erosion, and land suitability for agriculture.
- The soils of the watershed consist predominantly of clay and silty clay loam, followed by clay loam, silty clay, and loam. Soil depth varies from shallow (<25 cm) to very deep (>100 cm), with shallow soils occupying the largest proportion of the area. These soils generally have good moisture retention but are susceptible to erosion in upland areas.
- Land Use Land Cover (LULC) analysis indicates that agriculture is the dominant land use, covering about 70.5% of the total area, followed by forests (25.5%), water bodies (2.8%), and small areas of habitation. The landscape therefore reflects a strong dependence on agriculture with moderate natural vegetation cover.
- Soil erosion assessment shows that moderate erosion covers the largest portion of the watershed, while a significant proportion of land experiences severe to very severe erosion, especially on steep slopes and exposed uplands, highlighting the need for soil and water conservation measures.
- Soil fertility analysis reveals that most soils are neutral to slightly acidic and largely non-saline, making them generally suitable for agricultural production. However, the soils exhibit low to very high organic carbon, low nitrogen and phosphorus status, while potassium levels are generally very high. Micronutrient analysis indicates widespread zinc deficiency in the watershed soils.
- Rainfall-runoff analysis for the period 2014-24 indicates that nearly 47.5% of the annual rainfall is lost as surface runoff, with runoff mainly concentrated during July

and August. The high runoff percentage reflects the combined effect of intense monsoon rainfall, sloping terrain, and limited water harvesting structures.

- Groundwater potential zone (GWPZ) analysis shows that only 39.3% of the watershed falls under good to very good groundwater potential, while the remaining 60.7% lies in moderate to very poor potential zones, largely influenced by slope, rock structure, and soil depth.
- Agriculture in the watershed is largely rainfed and dominated by Kharif crops, particularly rice cultivated in lowland areas. Upland areas support crops such as finger millet (nagli), while horticultural crops including mango, cashew, coconut, banana, sapota, and jackfruit form an important component of the local agricultural economy.
- The gross cropped area of the watershed is 498.7 ha, with a net sown area of 421.3 ha, resulting in a cropping intensity of 118.4%. Rice occupies the largest share of the cropped area, while horticultural crops contribute significantly to farm income and crop diversification.
- The landholding pattern indicates that agriculture is dominated by small and marginal farmers, with marginal farmers (<1 ha) forming the largest group (42.57%). The average operational holding size is about 1.63 ha, which limits mechanization and adoption of advanced agricultural technologies.
- Morphometric analysis of the watershed revealed variations in drainage characteristics, basin geometry, and relief parameters among the three sub-watersheds (W1, W2, and W3). Sub-watershed W2 shows higher stream density, basin relief, and ruggedness, indicating greater susceptibility to runoff and erosion.
- Soil-site suitability analysis indicates that most of the watershed is marginally suitable for rice cultivation, while crops such as black gram, banana, coconut, sapota, and vegetables show moderate to marginal suitability depending on slope, soil depth, and drainage conditions.
- Based on the land resource inventory and spatial analysis of terrain, soil, slope, and land use, a site-specific Soil and Water Conservation (SWC) plan was prepared incorporating structural and vegetative measures such as contour bunding, bench terracing, farm ponds, check dams, afforestation, contour trenches, and silt detention structures to enhance soil moisture conservation and groundwater recharge.

5.2 CONCLUSION

The present study demonstrates the effective application of integrated geospatial techniques and field-based observations for comprehensive watershed assessment and planning under the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) framework. The systematic analysis of terrain, drainage characteristics, slope, soil resources, and land use land cover has enabled a detailed understanding of the hydrological and environmental conditions in the Dahan watershed, Palghar district. Although the watershed receives high annual rainfall under humid tropical climatic conditions, a considerable proportion of rainfall is lost as surface runoff due to steep slopes, undulating terrain, and limited water harvesting structures. As a result, water availability during the post-monsoon season becomes limited, affecting agricultural productivity and groundwater recharge.

The soil resource assessment reveals spatial variability in soil depth, texture, and fertility. While the soils are largely neutral, non-saline, and capable of supporting diverse crops, deficiencies in nitrogen, phosphorus, and zinc may constrain crop productivity if not properly managed. The presence of shallow soils and steep slopes in upland areas further increases the risk of soil erosion during intense monsoon rainfall. Morphometric analysis highlights the hydrological differences among the three sub-watersheds and indicates areas with higher runoff generation and erosion susceptibility. The identification of groundwater potential zones and rainfall–runoff relationships provide important insights for effective water resource management within the watershed. The evaluation of soil-site suitability for major crops shows that while rice remains the dominant crop, horticultural crops such as mango, cashew, banana, coconut, and sapota offer significant opportunities for income diversification and sustainable agricultural development. However, appropriate land management practices are required to overcome limitations related to slope, soil depth, and erosion risk.

Overall, the Land Resource Inventory (LRI) study of the Dahanu watershed provides a comprehensive scientific framework for watershed-based natural resource management. The proposed soil and water conservation interventions including mechanical structures, vegetative measures, and in-situ moisture conservation practices will help reduce runoff losses, control soil erosion, enhance groundwater recharge, and improve water availability for agriculture. Implementation of these watershed management strategies will contribute to sustainable land use, improved agricultural productivity, enhanced water security, and better livelihoods for farming communities in the Dahanu region of Palghar district.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