

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

(WDC-2.0)3/2021-22: Jath, Dist - Sangli



**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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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 Sangli (WDC-2.0)3/2021-22 watershed located within the Jath Taluka of Sangli District, Maharashtra, underlain with the characteristic basaltic terrain of the Deccan Plateau, with the Bor river (a tributary of the Bhima River basin) 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 were prepared using authenticated datasets and landforms were delineated. 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 Jath 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 Sangli (WDC-2.0) 3/2021-22 sub-watershed of Jath 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)3/202 1-22	Seloo	12	7	2657.5
Washim	Washim (WDC-2.0)5/202 1 -22	Malegaon	21	8	3806.1
Total			192		48626.9

CHAPTER2

JATH WATERSHED AT A GLANCE

2.1 Location and Extent

The watershed is located in Jath Taluka, one of the administrative divisions of Sangli District, within the Pune Revenue Division of Maharashtra. Jath Taluka is situated in the eastern part of Sangli District, which lies in the rain-shadow zone of the Western Ghats and is officially classified as a drought-prone region due to low and uneven rainfall patterns. In this part of the district, annual rainfall generally varies between 500 mm and 600 mm, significantly lower than western parts of the district.

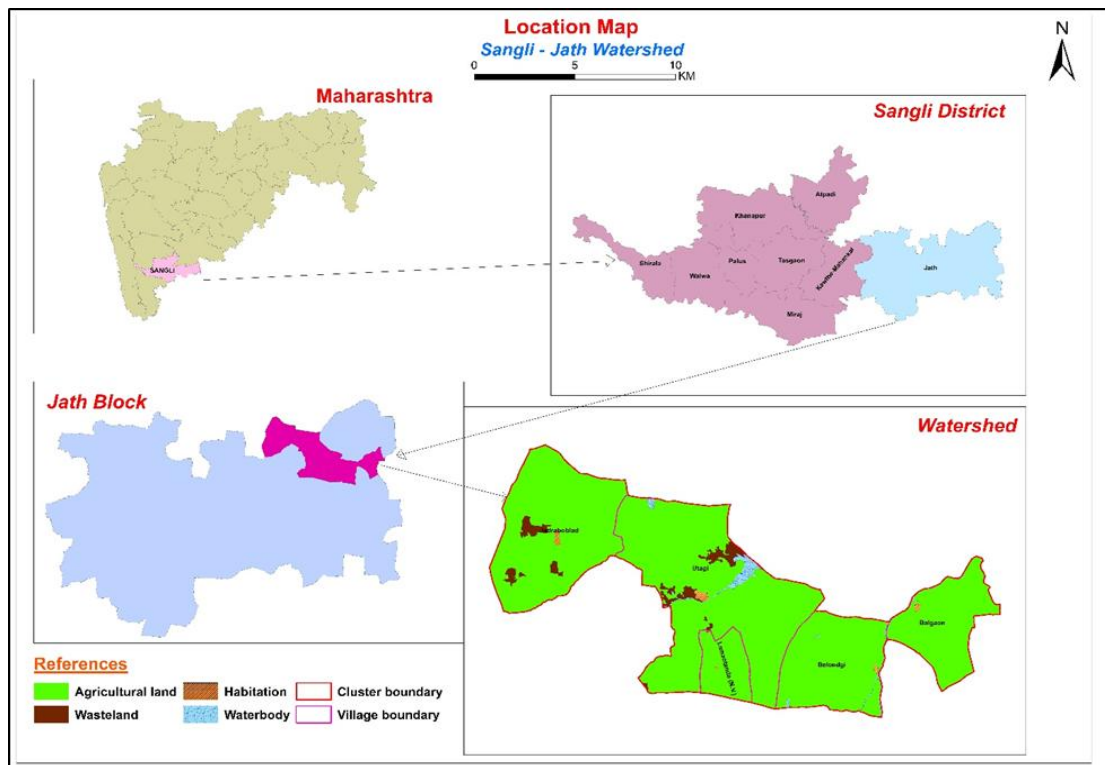


Fig. 2.1: Location map of the Jath watershed

Jath Taluka is predominantly rural, comprising dispersed villages with an agrarian economy that largely depends on rainfed agriculture. The landscape across the taluka is generally undulating to gently sloping with low-relief terrain, interspersed with shallow drainage lines and limited surface retention features. The absence of perennial watercourses, together with erratic and concentrated rainfall events, contributes to recurring water scarcity and water stress conditions in several parts of the taluka. Table 2.1 provides the general profile in respect of the watershed.

Table 2.1: Geographical and Administrative Profile

Sr. No.	Particulars	Details
1	District	Sangli
2	Taluka	Jath
3	Revenue Division	Pune
4	Total sub-watershed Area	Approx. 14237 ha (cluster area)
5	Villages	05 (Jadraboblad, Utagi, Lamantanda, Balgaon, Belondgi)
6	Major River	Bhima River but Bor river flows in watershed
7	Climate	Semi-arid
8	Average annual Rainfall	598 mm

2.2 Geology

Geologically, the Jath cluster is dominated by the Deccan Trap basalt, a hard rock formation that governs groundwater occurrence. This formation comprises thick, horizontally stratified basaltic lava flows, each typically having a porous, weathered basal unit, a dense central unit, and a vesicular upper layer. Red bole beds frequently separate the flows, marking distinct volcanic hiatuses. Groundwater is primarily stored in secondary porosity features-weathering, fracturing, and jointing within the massive basalts, while the vesicular layers enhance water movement through interconnected voids. Minor, localized deposits of alluvium, consisting of silt, sand, and gravel, are found along major river courses with thicknesses between 10 m and 40 m, supplementing the dominant hard rock aquifer system.

2.3 Geomorphology

The Jath cluster has an undulating topography, with elevations ranging from 473 m to 583 m above mean sea level. A key geomorphological feature is the Bor River. It is a non-perennial tributary of the Bhima River, which places the cluster in the vast Krishna River basin. This hydrographic context is vital for understanding water resources and geological processes and has historically dictated settlement and agriculture along its banks.

2.4 Physiography and Soil

Physiographically, the terrain is undulating, and the landforms present include uplands, midlands, and lowlands, along with pediplains and alluvial plains. Slopes vary from 0 to 26 percent rise, ranging from nearly level to moderately sloping terrain. These slope conditions influence runoff generation, infiltration, and soil erosion processes within the watershed.

Soils within the watershed are dominantly derived from the underlying basalt parent material and show textural variation. Based on field and secondary data, soils in the

watershed occur in the following decreasing order of areal coverage: clay, silt loam, clay loam, loam, and silty clay loam.

2.5 Climate

The watershed experiences a semi-arid, tropical monsoon climate, characteristic of the Deccan Plateau region. The climate is predominantly influenced by the southwest monsoon, which accounts for most of the annual rainfall, typically occurring from June to September. The watershed receives an average annual rainfall of about 598 mm, with significant inter-annual and spatial variability. Nearly 80-90% of the total precipitation occurs during the monsoon season, resulting in a strong dependence on seasonal rainfall for agriculture and groundwater recharge. The rainfall pattern is often erratic, leading to concerns related to droughts and water scarcity. Temperature variations are moderate to high throughout the year. The summer season, extending from March to May, is hot and dry, with maximum temperatures frequently reaching 39-40°C with a long period average value of 32.8°C. Winters, from November to February, are relatively cooler and dry, with minimum temperatures occasionally dropping to 19-21°C. Relative humidity is generally high during the monsoon (above 70%) and decreases significantly during the summer months. The region experiences high evaporation rates, especially during the pre-monsoon season, which increases water stress when proper irrigation facilities are not available.

2.6 Drainage

Jath cluster is a drought prone area in eastern Sangli district of Maharashtra. It is located in the Bor River, which is a tributary of the Bhima River. The Shirnandagi River is a tributary of Bor river and covers nearly one third of the watershed area. It flows from the northeast towards the west direction. Further, Bor River is joined by several seasonal and ephemeral tributaries, which enhance its discharge during the monsoon season. These streams contribute to local tanks, percolation structures, and downstream tributaries of the Bhima River. Surface flow is largely confined to the southwest monsoon period (June to September), while for the rest of the year, the streams remain dry, making the area heavily dependent on groundwater and water conservation structures for irrigation and domestic use.

2.7 Cropping Patterns, and Demography and Socioeconomics

2.7.1 Cropping Pattern

Cropping in Jath Taluka was previously characterized by dominant rainfed cultivation, with food-grain crops such as jowar (sorghum), bajra (pearl millet), and pulses constituting the primary agricultural system. These crops were dominant during the kharif season, reflecting the subsistence orientation of agriculture within the watershed.

The cropping pattern has undergone a transition toward non-food and cash crops, marked by an increase in the cultivation of sugarcane, cotton, oilseeds, and horticultural crops, such as pomegranate and grapes. This shift signifies a move toward commercialized agriculture.

2.7.2 Demographic and Socioeconomic Status

The Jath cluster is characterized by a 100 percent rural population, reflecting its agrarian foundation within the Sangli district. Socially, the taluka has the highest proportion of Scheduled Tribes in the district and records one of the lowest literacy rates, indicating developmental challenges in education and human capital formation. The demographic structure significantly influences livelihood patterns, with limited diversification beyond agriculture.

Economically, the region is heavily dependent on agriculture, with the highest proportion of agricultural laborers in the district. A significant segment of the population relies on wage-based farm employment, making household incomes vulnerable to rainfall variability and irrigation availability. This socio-economic profile highlights the need for improved irrigation infrastructure, livelihood diversification, and targeted development interventions to enhance resilience in this drought-prone landscape

2.8 Water Resources

2.8.1 Surface Water

The watershed is drained by the Bor River, which flows seasonally and contributes runoff only during the monsoon months. A secondary seasonal channel flows adjacent to Utagi village, which has facilitated the creation of a medium water storage reservoir. This reservoir captures part of the monsoon runoff, but its capacity and utility are constrained by siltation and limited catchment storage. There are no perennial streams within the study cluster, and surface water flow ceases rapidly after rainfall events due to the steepness of slopes and shallow soil cover.

2.8.2 Groundwater

Groundwater occurs mostly in weathered and fractured zones of basalt rock. According to the Dynamic Ground Water Resources of Sangli District (CGWB), 2024, annual extractable ground water resources place the region under the “safe” category, with the groundwater extraction level under 62.1%.

2.8.3 Irrigation and Water Management

The Jath cluster, located in the rain shadow region of Maharashtra, experiences low and erratic rainfall, making irrigation a critical determinant of agricultural productivity. Since the crop water requirements are rarely met through rainfall alone, farmers largely depend on supplemental irrigation sources. The Bor River serves as the nearest surface water source for irrigation in the cluster. In addition, the command areas of the Sankh Medium Irrigation Project and the Doddnala Medium Irrigation Project contribute to irrigation support, though their spatial coverage within the cluster may be limited. Groundwater extraction through borewells is also common due to increasing irrigation demand.

2.9 Constraints

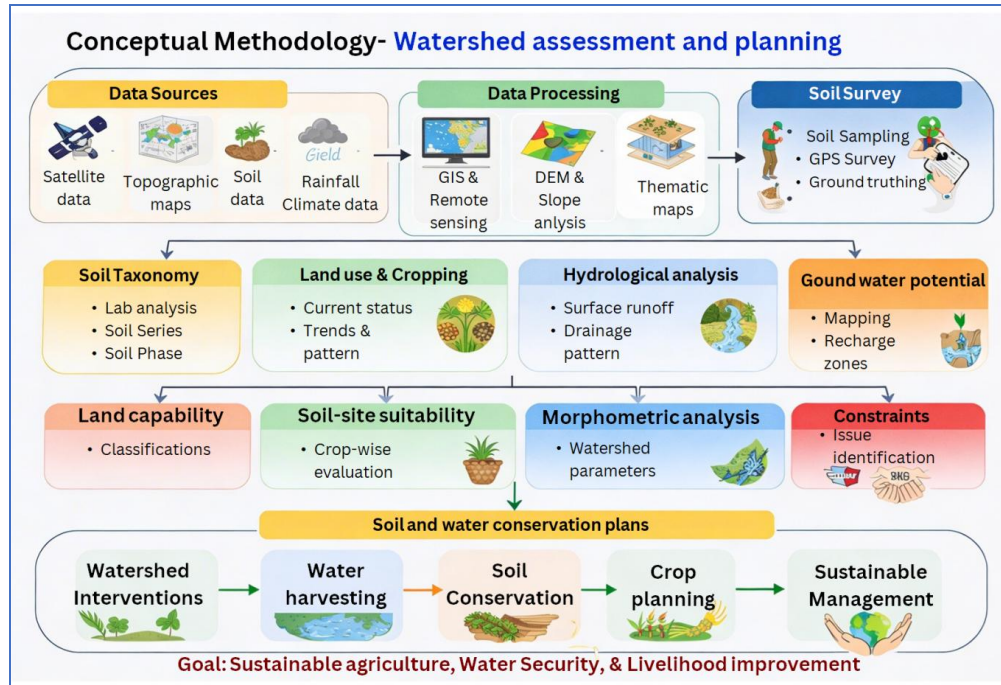
The following key issues were observed in the cluster villages, both through field surveys (2024-2025) and community consultations:

1. **Low Recharge:** Hard basaltic strata restrict infiltration, limiting aquifer recharge.
2. **Declining Water Availability:** Wells and handpumps show reduced yield after monsoon.
3. **Silted Surface Structures:** Existing tanks and reservoirs require desilting and maintenance.
4. **Non-perennial Surface Water Sources:** The Bor River and seasonal stream near Utagi village flow only during the monsoon, limiting year-round surface water availability.
5. **Stress on Agricultural Water Supply:** Due to the combination of low rainfall, limited irrigation support, and declining groundwater availability, agricultural activities face water stress.

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 landuse/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 Jath 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 Curve Number (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 Jath 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 Jath 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 unbundled 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 Jath watershed is presented in Table 4.1. During the kharif season, borewells contributed the highest share of irrigation with 69.8% of the total seasonal irrigation, indicating that borewells are the major source of irrigation during this period. Wells contributed 23.5%, while ponds accounted for only 6.7%. Rainfed areas recorded 0% irrigation, indicating that these lands depend entirely on rainfall without any supplemental irrigation. In the *rabi* season, borewells contributed 75.6%. Ponds contributed 19.7% of the total irrigation, while wells accounted for 4.6% with 15 farmers. During the summer season, ponds are the major irrigation source, contributing 90.3% of the total summer irrigation, whereas borewells contribute only 9.6%. Wells did not contribute to irrigation during the summer season.

Overall, the results indicate that borewells are the primary source of irrigation during the Kharif and Rabi seasons, while ponds become the dominant irrigation source during the summer season. This pattern highlights the significant role of groundwater resources during the main cropping seasons and the importance of surface water storage structures for irrigation during the summer season.

Table 4.1 Seasonal Distribution of Irrigation Sources in the Watershed

Sr. No.	Number of Farmers Interviewed (n)	Irrigation Source	Seasonal Water Availability	Contribution to Season's Total Irrigation (%)
1	141	Borewell	Kharif	69.8
2	108	Borewell	Rabi	75.6
3	12	Borewell	Summer	9.6
4	41	Pond	Rabi	19.7
5	18	Pond	Summer	90.3
6	10	Pond	Kharif	6.7
7	21	Rainfed	Kharif	0
8	10	Rainfed	Rabi	0
9	41	Well	Kharif	23.5
10	15	Well	Rabi	4.6

4.1.2 Cropping Pattern

The cropping pattern in the Jath watershed cluster is determined by the distribution of rainfall and the availability of irrigation. From the total farmers interviewed, it is found that the Net Sown Area for the cluster is 543 ha, with the Gross Cropped Area being 687 ha, which yields a cropping intensity calculated as

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

$$\text{Cropping intensity}(\%) = \frac{687}{543} \times 100 = 126.5\%$$

The cropping intensity of 126.5% indicates moderate crop intensity. Irrigation facilities are available for the farmers, but the water availability is limited up to the Rabi season, which restricts the cropping during summer months. Among, 201 farmers interviewed about 178 farmers have no access to irrigation, while the remaining farmers depend on rainfed agriculture.

Table 4.2 Crop-wise Distribution in the Jath watershed

Sr. No.	Season	Crop	No. of Farmers Interviewed (n)	Irrigation Type	Total Cropped Area (%)	Productivity (kg/ha)
1	Perennial	Pomegranate	112	Irrigated	16.8	10,000
2	Perennial	Grapes	109	Irrigated	18.3	22,000
3	Kharif	Tur	176	Irrigated	28.8	1,300
4	Kharif	Tur	22	Rainfed	2.3	700
5	Kharif	Bajra	161	Irrigated	11.5	1,600
6	Kharif	Bajra	19	Rainfed	3.3	900
7	Rabi	Maize	156	Irrigated	13.2	3,500
8	Rabi	Jowar	57	Irrigated	5.5	1,500
		Total			100%	

The majority of the farmers in the watershed have access to irrigation facilities, with a minor rainfed area. However, the availability of irrigation water is restricted to the Kharif and Rabi seasons, which results in seasonal fallowing during the summer and limits the cropping intensity to 126.5%.

The data presented in Table 4.2 indicate that perennial horticultural crops occupied 35.2% of the total cropped area. Irrigated Tur accounts for 28.8% of the total cropped area, indicating Tur as a major seasonal crop.

In the rabi season, the highest area was observed under Maize cultivation (13.2%) and Jowar (Sorghum) cultivation (5.5%). Rabi cultivation relies on assured irrigation. However, a major constraint is the complete absence of irrigation facilities during the summer months. This lack of summer water prevents the cultivation of a third crop such as vegetables, pulses, or fodder, limiting the overall cropping intensity and has no

opportunity of maximizing land use, increasing farm incomes, and diversifying production.

4.1.3 Socioeconomic Status

4.1.3.1 Land holding pattern

The landholding pattern of farmers in the Jath watershed is presented in Table 4.3. The results indicate that the majority of farmers belong to the marginal and small landholding categories. From the table, it was observed that marginal farmers (<1 ha) constitute the highest number of farmers, with 82 respondents (41.0%) having an average landholding of 0.7 ha, which is followed by small farmers (1–2 ha) with 64 respondents (32.0%) possessing an average landholding of 1.5 ha.

Semi-medium farmers (2–4 ha) comprise 28 respondents (14.0%) with an average landholding of 2.8 ha, while medium farmers (4–10 ha) represent 22 respondents (11.0%) with an average landholding of 5.1 ha. Only a small proportion of farmers fall under the large farmer category (>10 ha), comprising 4 respondents (2.0%) with an average landholding of 11.8 ha.

The overall average landholding size of the study area was found to be 2.4 ha, indicating that agriculture in the watershed area is characterized by small and marginal landholdings.

Table 4.3 Land holding pattern in Jath watershed

Category	Criteria Land (ha)	No. of Farmers Interviewed	Farmers (%)	Average Land Holding (ha)
Marginal Farmers	< 1	82	41.0	0.7
Small Farmers	1 – 2	64	32.0	1.5
Semi-Medium Farmers	2 – 4	28	14.0	2.8
Medium Farmers	4 – 10	22	11.0	5.1
Large Farmers	> 10	4	2.0	11.8
Total		200	100	2.4

4.1.3.2 Income distribution

The average annual income of farmers from different crops in the Jath watershed is presented in Table 4.4. Maize occupies the largest cropped area (18.8%) with an average income of 74,600 Rs, indicating its importance as a major income-contributing crop in the watershed, which was followed by tur, which covers 17.4% of the cropped area with an average income of 68,900 Rs. Jowar has 16.2% of the cropped area with an average income of 29,750 Rs, while bajra covers 14.5% of the cropped area with an average income of 21,800 Rs. Wheat occupies the smallest area among field crops (6.6%) with an average income of 34,500 Rs.

Horticultural crops like grapes and pomegranate generate significantly higher income compared to field crops. Grapes covered 12.6% of the cropped area and had the highest average income of 4,25,000 Rs. Similarly, pomegranate covered 13.9% of the cropped area with an average income of 3,10,000 Rs.

The income pattern indicates that field crops such as maize, tur, jowar and bajra occupy a larger share of the cropped area but the horticultural crops like grapes and pomegranate contribute higher income to farmers.

Table 4.4 Average annual income of farmers in Jath watershed

Name of Crops	No. of Farmers Interviewed (n)	Crop Area (%)	Average Income (Rs.)
Bajra	76	14.5	21,800
Jowar	82	16.2	29,750
Maize	95	18.8	74,600
Tur	88	17.4	68,900
Grapes	24	12.6	4,25,000
Pomegranate	30	13.9	3,10,000
Wheat	20	6.6	34,500
Total	200	100	

4.1.3.3 Education

The educational profile of the population in the villages of the Jath watershed is presented in Table 4.5. In Balgaon, 34% of the population is illiterate, while 36% have primary education, 17% secondary education, 9% higher secondary education and 4% have completed higher studies. In Lamantanda, 29% of the population is illiterate, with the highest under primary education (39%), followed by secondary education (18%), higher secondary education (10%) and higher studies (4%).

Similarly, in Utagi village, 31% of the population is illiterate, while 33% have primary education, 21% secondary education, 10% higher secondary education and 5% have completed higher studies. Jadarboblad shows comparatively lower illiteracy (27%) among the villages, with 37% under primary education, 22% secondary education, 9% higher secondary education and 5% higher studies. Belonggi recorded 30% illiteracy, while 35% of the population had primary education, 19% secondary education, 11% higher secondary education and 5% higher studies.

The results indicate that primary education constitutes the largest proportion of the population in all villages, while a relatively smaller percentage of respondents have attained higher secondary education and higher studies. This educational pattern suggests moderate literacy levels in the watershed, which may influence awareness, decision-making capacity and adoption of improved agricultural practices.

Table 4.5 Education profile of villages in Jath watershed by population

Village	No Education (%)	Primary (%)	Secondary (%)	Higher Secondary (%)	Higher Studies (%)
Balgaon	34	36	17	9	4
Lamantanda	29	39	18	10	4
Utagi	31	33	21	10	5
Jadarboblad	27	37	22	9	5
Belondgi	30	35	19	11	5

4.2 Land-use/Land-cover

LULC classification is undertaken to quantify how the watershed area is distributed among different land use categories. This helps in identifying the dominance of agriculture, the extent of wastelands, and the presence of water bodies and built-up areas. Such classification provides a scientific basis for watershed planning, resource management, and prioritization of conservation measures. The classification of the area reveals that agriculture is the predominant land use type, occupying 13590.3 ha, and constitutes approximately 95.5% of the total area (Table 4.6 and Fig. 4.1). Wastelands represent 2.6% of the area, which may indicate land degradation or areas unsuitable for cultivation. Waterbodies are limited to 220 ha, making up 1.5% 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 wastelands.

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

Land use	Area(ha)	Percent (%)
Agriculture	13590.3	95.5
Habitation	62.2	0.4
Waterbody	220	1.5
Wasteland	365.4	2.6
Total	14237.9	100.0

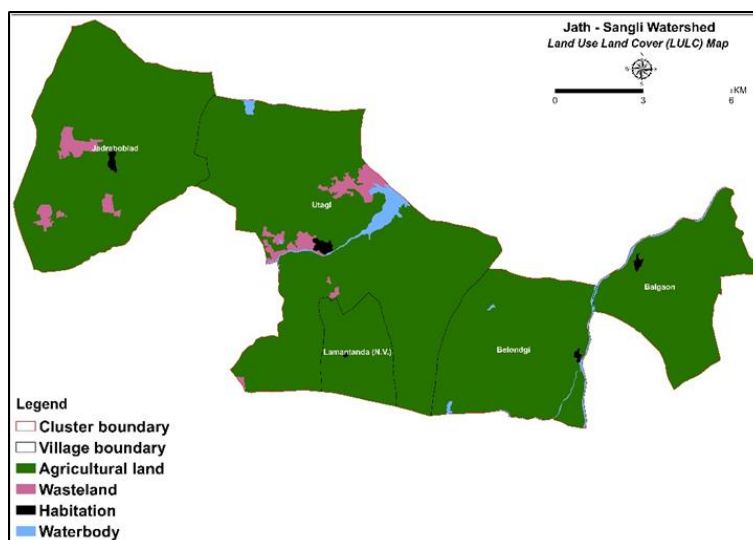


Fig. 4.1: Land-use/land-cover map

4.3 Landform Delineation

The landform pattern of the Jath watershed, Sangli district, shows a predominantly undulating landscape with noticeable variation in surface form and relief. Large stretches of gently rolling midland and lowland areas define the general terrain, giving the watershed its characteristic undulating appearance. Alluvial and plain landforms are mainly observed along valley floors and drainage lines, forming relatively flat stretches within the watershed. The upland areas represent higher ground with gentle to moderate undulations. Waterbodies and habitation occupy only a very small portion of the area. Overall, the watershed presents a diverse mix of landforms, reflecting a naturally varied geomorphic setting. The landform map of the watershed is presented in Fig. 4.2. The descriptions of each landform are presented in Table 4.7.

Table 4.7: Landform features existing in Jath watershed

Landform	Area(ha)	Percent (%)
Undulating Midland	6839.2	48.0
Undulating Lowland	2519.6	17.7
Alluvial Plain	1658.2	11.7
Plain	1571.8	11.0
Undulating Upland	1366.9	9.6
Waterbody	220.1	1.6
Habitation	62.2	0.4
Total	14237.9	100.0

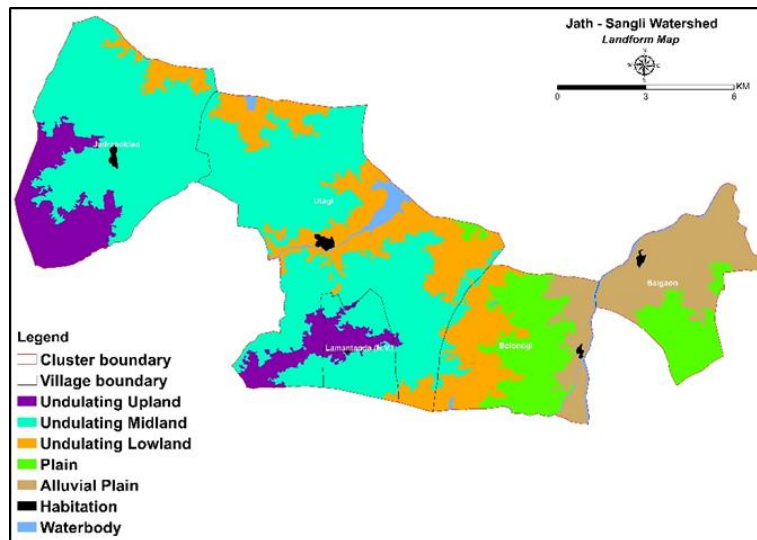


Fig. 4.2: Landform map of Jath watershed

4.4 Soil series and phases

Twelve soil series have been identified and mapped with 31 soil mapping units (phases of series) (Fig 4.3). The taxonomic classification and mapping legend of the soil series were shown in Table 4.8. The detailed descriptions of each series are given in Table 4.9.

Table 4.8. Dominant soil series identified in the watershed

Sr. No.	Soil Series	Area(ha)	Percent (%)
1	Belundgi	3315.0	23.3
2	Utagi2	1752.3	12.3
3	Balgaon1	1658.2	11.7
4	Utagi	1180.8	8.3
5	Lamntanda	1107.5	7.8
6	Utagi1	957.4	6.7
7	Jadarboblad1	927.4	6.5
8	Lamntanda1	902.5	6.3
9	Utagi3	767.3	5.4
10	Balgaon	669.3	4.7
11	Jadarboblad	439.4	3.1
12	Jadarboblad2	278.5	2.0
13	Waterbody	220.1	1.6
14	Habitation	62.2	0.4
	Total	14237.9	100.00

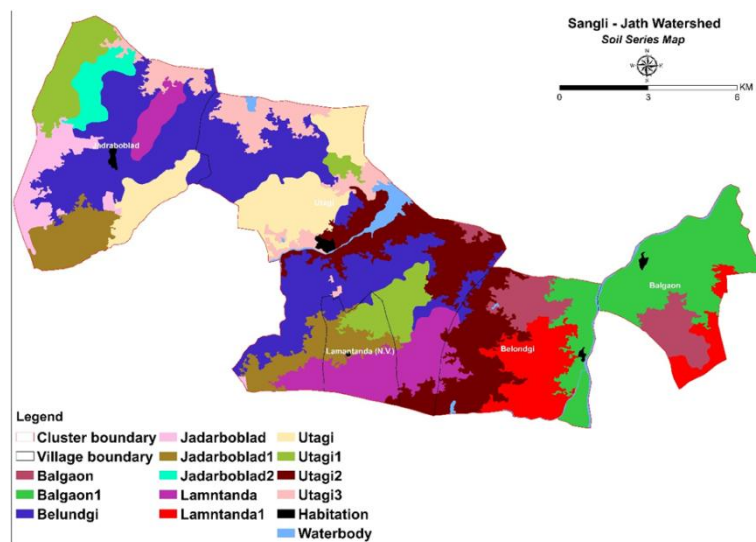


Fig. 4.3: Soil series map of Sangli-Jath watershed

Table 4.9. Soil phases existing in Jath watershed

Sr. No.	Phase	Area(ha)	Percent (%)
1	Bel2mB2g2	1640.0	11.5
2	Bel2mD2g2	1278.2	9.0

3	Uti2mC2g3	1276.7	9.0
4	Blg6mB2	1215.8	8.5
5	Jdb2mB2g3	927.4	6.5
6	Lmn3mB2	673.7	4.7
7	Uta1mD2g3	489.9	3.4
8	Uti2mB3g2	475.6	3.3
9	Utg2dB2g3	473.0	3.3
10	Utg2gB2g2	413.4	2.9
11	Bel2mD2g3	396.7	2.8
12	Ugi1mD3g4	352.6	2.5
13	Bal2mB2g3	344.9	2.4
14	Uta1eC2g1	342.2	2.4
15	Lam1mB2g2	326.1	2.3
16	Bal2mB2g2	324.4	2.3
17	Lam1eD2g2	306.1	2.2
18	Jad1mB2g3	288.0	2.0
19	Jbl3mC2g1	278.5	2.0
20	Lam1eD3g2	256.5	1.8
21	Blg6mA1	254.5	1.8
22	Uta1fB2g2	240.4	1.7
23	Waterbody	220.1	1.6
24	Lam1fB2g2	218.9	1.5
25	Ugi1mD2g3	213.9	1.5
26	Ugi1mC2g2	200.8	1.4
27	Blg6mA2	187.8	1.3
28	Lmn3mB2g2	179.7	1.3
29	Jad1mD3g4	151.5	1.1
30	Uta1mC2g2	108.3	0.8
31	Utg2fB2g3	71.0	0.5
32	Habitation	62.2	0.4
33	Lmn3mC2g2	49.2	0.4
		14237.9	100.0

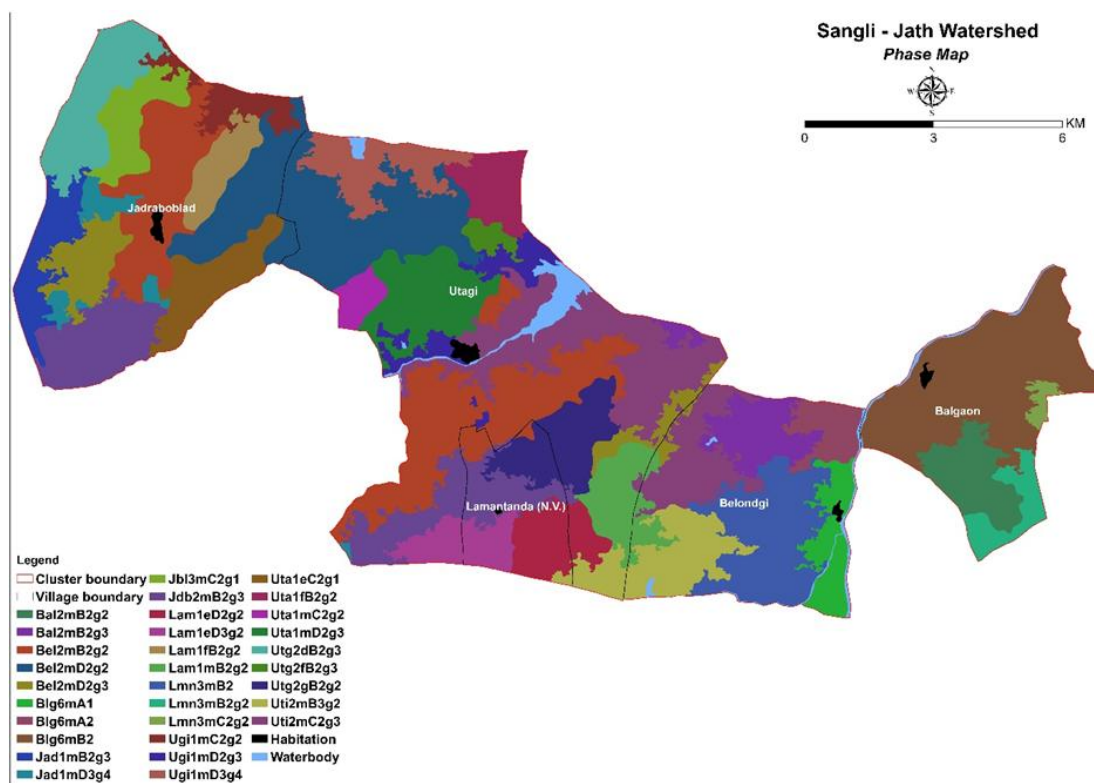


Fig. 4.4: Soil Phase map of Sangli-Jath watershed

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 very gently sloping (1-3%) i.e. 59.6% followed by gently sloping (3-8%) i.e. 35.3% and level to nearly (0-1) i.e. 3.1%.

Table: 4.10. Land slope classes in Jath watershed

Sr.No.	Slope Class (%)	Area (ha)	TGA (%)
1	Level to nearly level (0 - 1)	442.3	3.1
2	Very gently sloping (1 - 3)	8491.9	59.6
3	Gently sloping (3 - 8)	5021.3	35.3

4	Habitation	62.1	0.4
5	Waterbody	220.0	1.5
	Total	14237.9	100.0

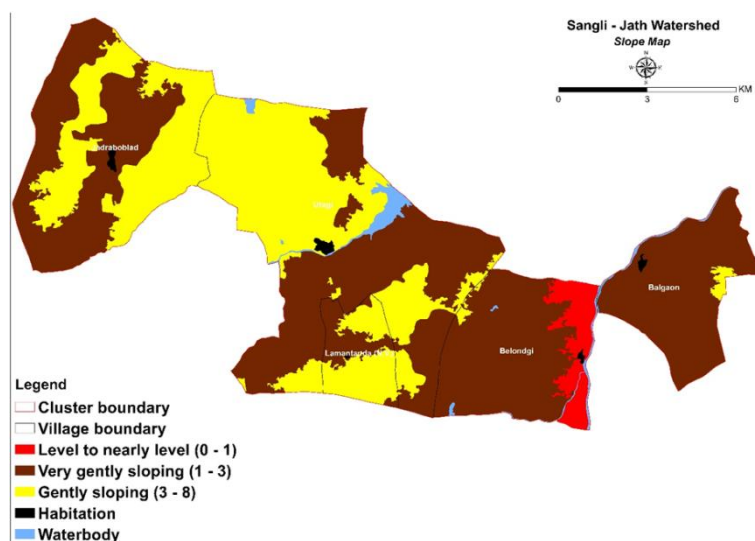


Fig. 4.5: Slope map of Sangli-Jath watershed

4.5.2 Soil Erosion

Soil erosion in the Jath watershed varies from very slow to severe depending on local terrain and land conditions (Table 4.11). The analysis indicates that the majority of the watershed area, about 87.6%, falls under the moderate erosion category, suggesting that soil loss is present but generally manageable with proper conservation practices. A small portion of the area, 1.8%, experiences very slow erosion, indicating relatively stable soil conditions with minimal loss. However, about 8.7% of the watershed is affected by severe erosion, representing zones where soil degradation is more pronounced and requires immediate attention.

Table 4.11: Soil erosion status in Jath watershed

Sr. No.	Erosion class	Area (ha)	Percent (%)
1	Very Slight	254.5	1.8
2	Moderate	12465.0	87.6
3	Severe	1236.1	8.7
4	Habitation	62.2	0.4
5	Waterbody	220.0	1.6
	Total	14237.9	100.0

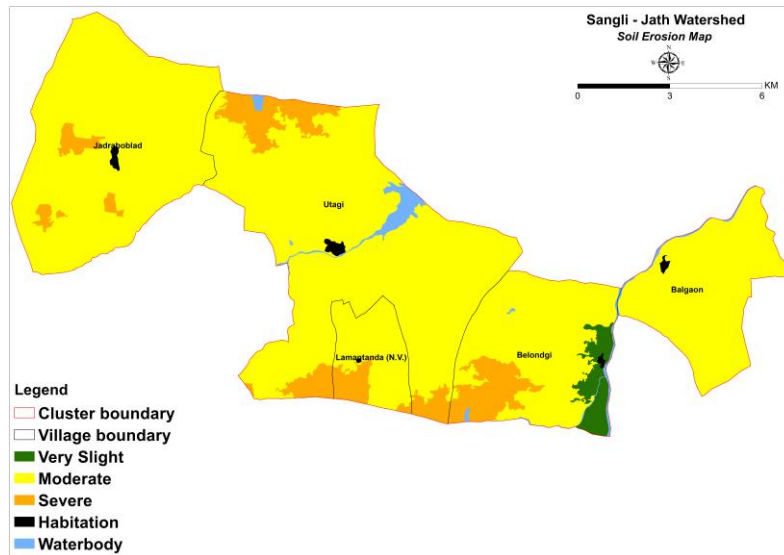


Fig. 4.6: Erosion map of Sangli-Jath watershed

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 in the watershed (Fig. 4.7) varies from shallow (<25 cm) to very deep (> 100 cm). Area wise distribution of the data (Table 4.12) showed that maximum area was under moderate (44.8%) followed by shallow (33.2%), very deep (11.7%) and moderately deep soils (8.3%).

Table 4.12. Soil depth classes in Jath watershed

Sr. No.	Depth Class (cm)	Area (ha)	TGA (%)
1	Shallow (< 25)	4732.5	33.2
2	Moderate (25 - 50)	6384.0	44.8
3	Moderately Deep (50 - 75)	1181.0	8.3
4	Very Deep (> 100)	1658.2	11.7

5	Habitation	62.2	0.4
6	Waterbody	220.0	1.6
	Total	14237.9	100.0

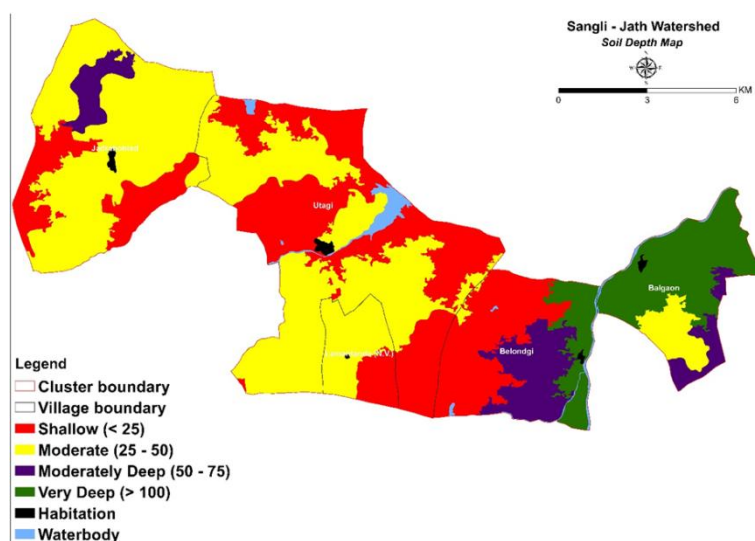


Fig. 4.7: Depth map of Sangli-Jath watershed

4.5.4 Surface texture

Soil texture plays a vital role in agriculture by directly influencing water retention, root development, and nutrient availability to plants. Soils with a balanced texture, such as loam, provide optimal conditions for plant growth by allowing good water drainage while retaining enough moisture for the roots. Clay soils, though rich in nutrients, can become compacted and poorly drained, while sandy soils may drain too quickly and lack essential nutrients. Understanding soil texture helps farmers make informed decisions about irrigation practices, crop selection, and the appropriate use of soil amendments. The texture of the watershed area soils was grouped into six classes (Table 4.13, Fig. 4.8). Among the different classes clay texture was found in 81.7% area followed by silty loam (6.4%), clay loam (3.7%), loam (3.3%) and silty clay loam (2.9%). Based on the texture, the soils of the watershed, particularly the moderately deep to deep soils are expected to be fertile and produce good crops.

Table 4.13. Soil texture distribution in Jath watershed

Sr.No.	Texture	Area (ha)	TGA (%)
1	Clay	11634.2	81.7
2	Silt Loam	904.8	6.4
3	ClayLoam	530.3	3.7
4	Loam	473.0	3.3
5	Silty Clay Loam	413.4	2.9
6	Waterbody	220.1	1.6
7	Habitation	62.2	0.4
	Total	14237.9	100.00

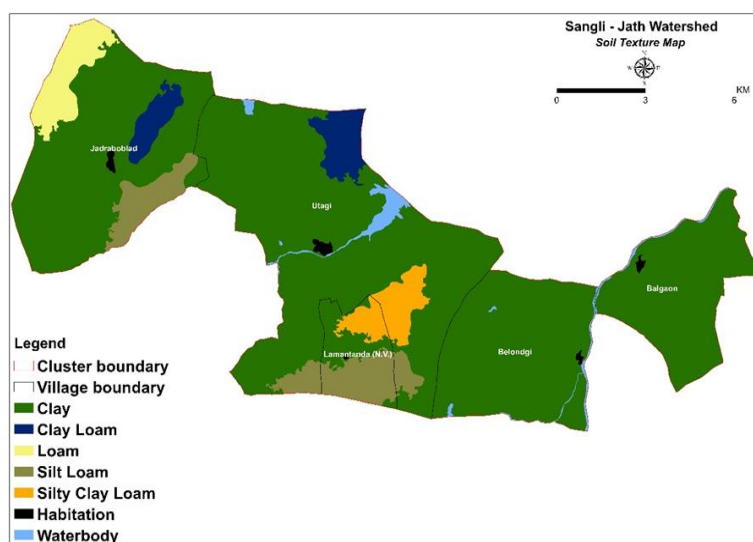


Fig. 4.8: Soil texture map of Sangli-Jath watershed

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 pH value also helps to determine the quantity of amendments to be added for ameliorating acidity or alkalinity. About 78% of the soils in the watershed (Table 4.14, Fig. 4.9) are predominantly moderately alkaline in reaction (pH 8.0-9.0), followed by slightly (7.5-8.0) and strongly alkaline (pH 9.0-10).

Table 4.14. Soil pH distribution in Jath watershed

Sr.No.	Soil pH	Area (ha)	TGA (%)
1	Slightly Alkaline (7.5 - 8.0)	2243.8	15.8
2	Moderately Alkaline (8.0 - 9.0)	11088.9	77.9
3	Strongly Alkaline (9.0 - 10.0)	622.9	4.4
4	Habitation	62.2	0.5
5	Waterbody	220.1	1.6
	Total	14237.9	100.0

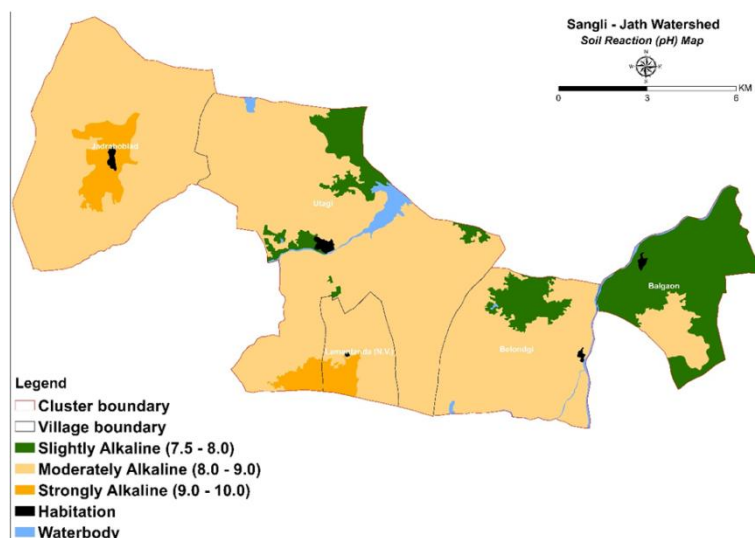


Fig. 4.9: Soil pH map of Sangli-Jath watershed

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 EC of the soils of the watershed were well within the permissible limit of salinity (Table 4.15, Fig 4.10) and will not cause any detrimental effect on crop growth.

Table 4.15. Soil salinity classes in Jath watershed

Sr. No.	Electrical conductivity (dSm^{-1})	Area (ha)	TGA (%)
1	Normal (< 1)	13955.7	98.0
2	Habitation	62.2	0.4
3	Waterbody	220.1	1.6
	Total	14237.9	100.0

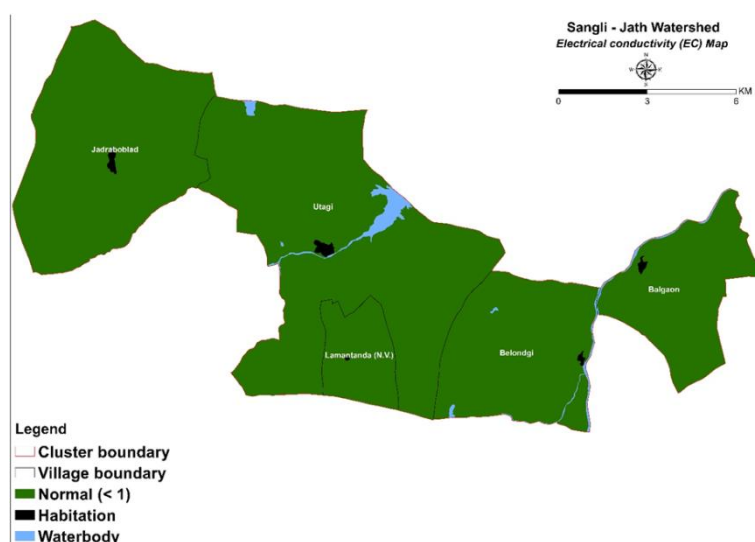


Fig. 4.10: Soil EC map of Sangli-Jath watershed

4.5.7 Calcium carbonate (CaCO₃) content

The soils of the watershed are generally calcareous in nature with the CaCO₃ content ranging from moderate to very high (>10%). Semi-arid climatic features with low rainfall and high PET favour release of substantial amount of alkali bicarbonates and carbonates into the soil solution, thereby rendering the soils calcareous. As can be inferred from Table 4.16 and Fig. 4.11, a large part of the watershed area (62.5%) contains more than 10% CaCO₃ in soil, which could pose problems to normal crop growth.

Table 4.16. Extent of calcareousness in soils of Jath watershed

Sr.No.	CaCO ₃ content (%)	Area (ha)	TGA (%)
1	Moderately High (2.0 - 5.0)	702.4	4.9
2	High (5.0 - 10.0)	4360.4	30.6
3	Very High (> 10.0)	8892.8	62.5
4	Habitation	62.2	0.4
5	Waterbody	220.1	1.6
	Total	14237.9	100.0

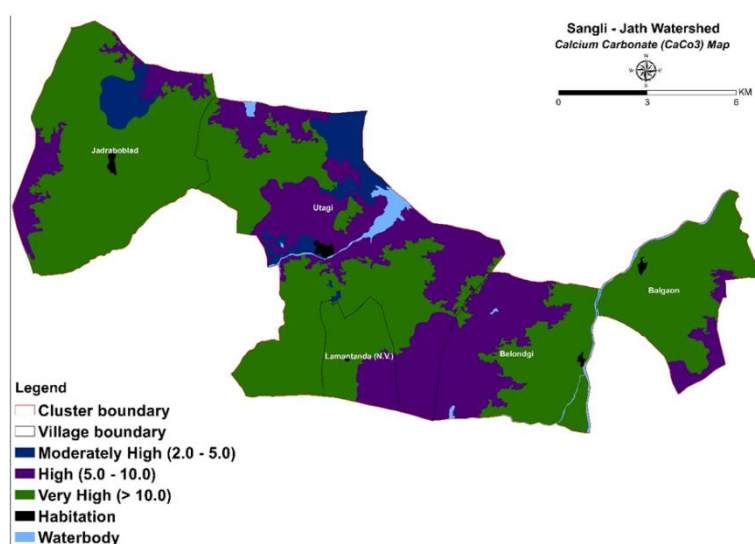


Fig. 4.11: Status of soil calcareousness in Sangli-Jath watershed

4.5.8 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. Soils of Sangli-Jath watershed supported medium to moderately high SOC content, which can be inferred from Table 4.17 and Fig. 4.12. This is also indicated by the moderate-deep soils and loamy texture prevalent in the watershed. However, there is an immense need for application of organic manures by the farmers in the watershed area in general, and in about 32% of the area exhibiting low SOC. High SOC content was found to occur in approximately 1700 ha of the watershed.

Table 4.17. Soil organic carbon status of Jath watershed

Sr. No.	Organic carbon (%)	Area (ha)	TGA (%)
1	Very Low (< 0.20)	332.2	2.3
2	Low (0.21 - 0.40)	4232.5	29.7
3	Medium (0.41 - 0.60)	5964.0	41.9
4	Moderately High (0.61 - 0.80)	1650.1	11.6
5	High (0.81 - 1.00)	1776.9	12.5
6	Habitation	62.2	0.4
7	Waterbody	220.1	1.6
	Total	14237.9	100.00

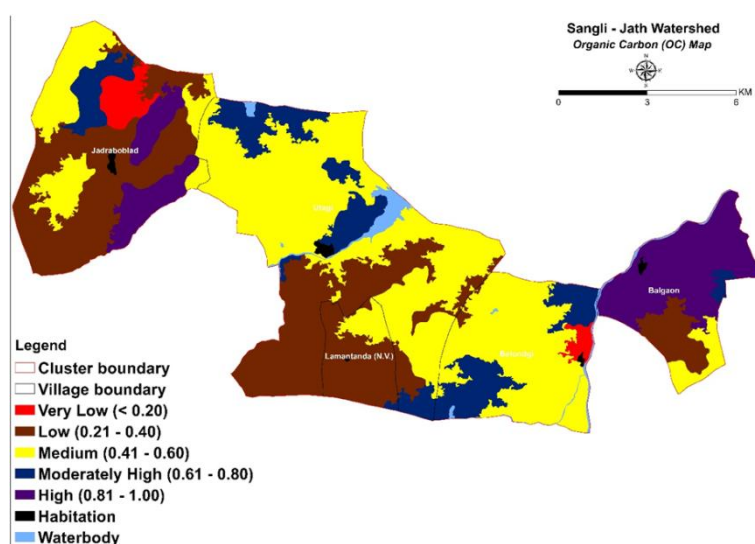


Fig. 4.12: Soil organic carbon map of Sangli-Jath watershed

4.5.9 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 agricultural soils of watershed are inherently deficient in available N content. As seen from Table 4.18 and Fig. 4.13. The soils of Sangli-Jath watershed area are falls under very low N values (<140 kg ha⁻¹) i.e. 53.1% area, followed by low N content (141-280 kg ha⁻¹) i.e. 44.9% is a matter of concern. Therefore, it is advocated to apply the nitrogenous fertilizers as per crop needs to maximize crop yields in the watershed area.

Table 4.18: Available N content in soils of Jath watershed

Sr.No.	Available N (kg ha ⁻¹)	Area (ha)	TGA (%)
1	Very Low (< 140)	7559.9	53.1
2	Low (141 - 280)	6395.8	44.9
3	Habitation	62.2	0.4
4	Waterbody	220.1	1.6
	Total	14237.9	100.0

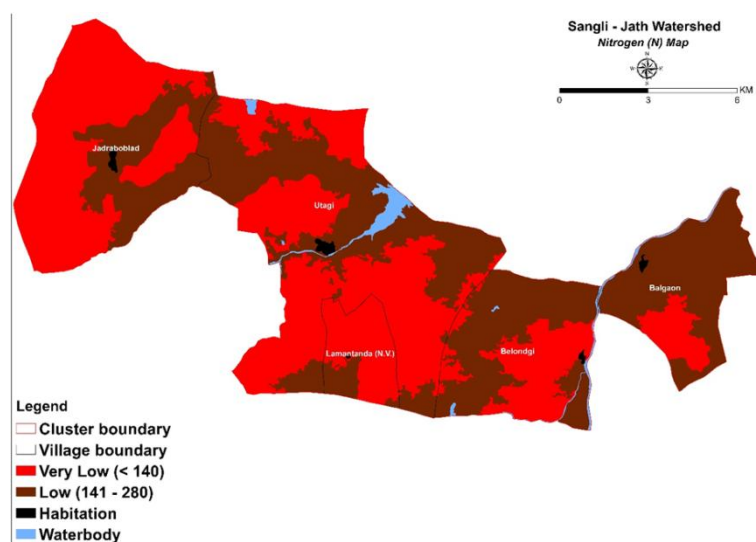


Fig. 4.13: Available soil nitrogen map of Sangli-Jath watershed

4.5.10 Available Phosphorous (P)

The P content of the agricultural soils of the watershed (Table 4.19, Fig. 4.14) ranged from very low (<15 kg ha⁻¹) to low (16-30 kg ha⁻¹), with the highest area was under very low P status (88.4%) followed by low (8%) and medium (1.3%). The vast majority (three-fourths) of the area under very low to low status points to the fact that the farmers do not apply phosphatic fertilizers to soils, and/or substantial amounts of applied fertilizer P is fixed in the soils owing to their calcareous nature.

Table 4.19: Available P content in soils of Jath watershed

Sr. No.	Available P (kg ha ⁻¹)	Area (ha)	TGA (%)
1	Very Low (< 15)	12586.9	88.4
2	Low (16 - 30)	1137.2	8
3	Medium (31 - 50)	179.7	1.3
4	Moderately High (51 - 65)	51.9	0.4
5	Habitation	62.2	0.4
6	Waterbody	220.1	1.6
	Total	14237.9	100.0

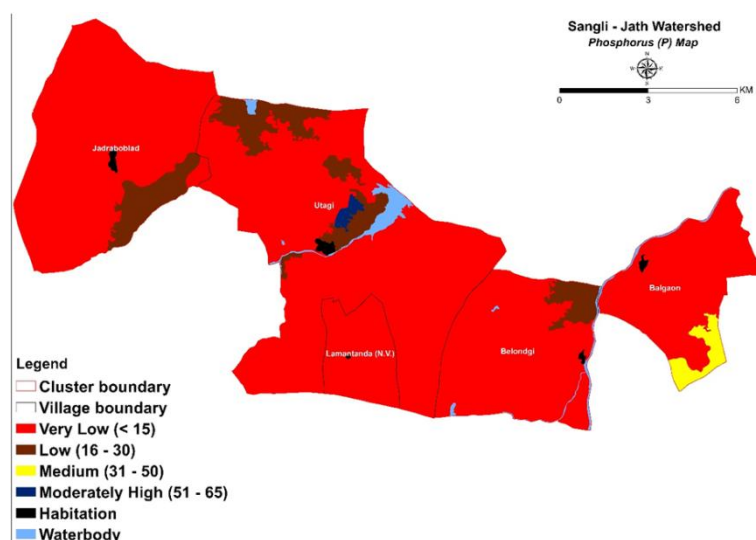


Fig.4.14: Available soil Phosphorus map of Sangli-Jath watershed

4.5.11 Available Potassium (K)

Five classes of available K status (Table 4.20, Fig. 4.15) were observed in the watershed soils. More than half of the watershed (54.7 %) soils exhibited very low available K. Therefore, external application of potassic fertilizers is necessary for the combined area of 12% exhibiting low (121-180 kg ha⁻¹) to medium (181-240 kg ha⁻¹) K content.

4.5.12 Micronutrient status of soils

Five classes of available Fe were found in the watershed. Table 4.21 and Fig. 4.16 indicate that about 83.8% of the watershed area is deficient in bioavailable Fe, calling for immediate attention in terms of its soil or foliar application through different fertilizer products. On the other hand, about 1.3% of the watershed area was categorized as moderately high (6.5-8.5 mg kg⁻¹) in DTPA-extractable Fe. Approximately 4.2% of the watershed area was found to be deficient in plant-available Mn content, while majority of the area is adequately supplied with Mn (Table 4.22, Fig. 4.17). Soils of the entire watershed are sufficient with respect to DTPA-extractable Cu (Table 4.23, Fig. 4.18), whereas more than 76% of the soils exhibit deficiency in bioavailable Zn (Table 4.24, Fig. 4.19), necessitating external Zn fertilization by the farmers.

Table 4.20: Available K content of soils of Jath watershed

Sr. No.	Available K (kg ha ⁻¹)	Area (ha)	TGA (%)
1	Very Low (< 120)	7790.6	54.7
2	Low (121 - 180)	1723.5	12.1
3	Medium (181 - 240)	550.0	3.9
4	Moderately High (241 - 300)	1570.8	11.0
5	Very High (> 360)	2320.7	16.3
6	Habitation	62.2	0.5
7	Waterbody	220.1	1.6
	Total	14237.9	100.0

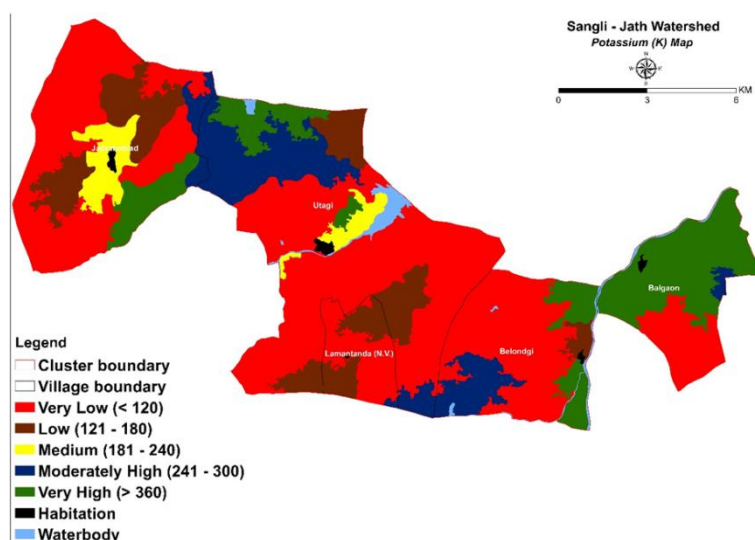


Fig. 4.15: Available soil Potassium map of Sangli-Jath watershed

Table 4.21: Available Fe content in the soils of Jath watershed

Sr. No.	Available Fe (mg kg ⁻¹)	Area (ha)	TGA (%)
1	Very Low (< 2.5)	6390.8	44.9
2	Low (2.5 - 4.5)	5536.4	38.9
3	Medium (4.5 - 6.5)	1848.8	13.0
4	Moderate High (6.5 - 8.5)	179.7	1.3
5	Habitation	62.2	0.4
6	Waterbody	220.1	1.6
	Total	14237.9	100.0

Table 4.22: Available Mn content in the soils of Jath watershed

Sr. No.	Available Mn (mg kg ⁻¹)	Area (ha)	TGA (%)
1	Very Low (< 1.0)	590.3	4.2
2	Medium (1.3 - 5.0)	10849.3	76.2
3	Moderately High (5.0 - 7.0)	1814.3	12.7
4	High (7.0 - 9.0)	522.2	3.7
5	Very High (> 9.0)	179.7	1.3
6	Habitation	62.2	0.4
7	Waterbody	220.1	1.6
	Total	14237.9	100.0

Table 4.23: Available Cu content in the soils of Jath watershed

Sr. No.	Available Cu (mg kg ⁻¹)	Area (ha)	TGA (%)
1	High (0.8 - 1.0)	2180.0	15.3
2	Very High (> 1.0)	11775.7	82.7
3	Habitation	62.2	0.4
4	Waterbody	220.1	1.6
	Total	14237.9	100.0

Table 4.24: Available Zn content in the soils of Jath watershed

Sr. No.	Available Zn (mg kg ⁻¹)	Area (ha)	TGA (%)
1	Very Low (< 0.3)	4644.9	32.6
2	Low (0.3 - 0.6)	6265.5	44.0
3	Medium (0.6 - 0.9)	2922.4	20.5
4	High (1.2 - 1.8)	71.0	0.5
5	Very High (> 1.8)	51.9	0.4
6	Habitation	62.2	0.4
7	Waterbody	220.1	1.6
	Total	14237.9	100.0

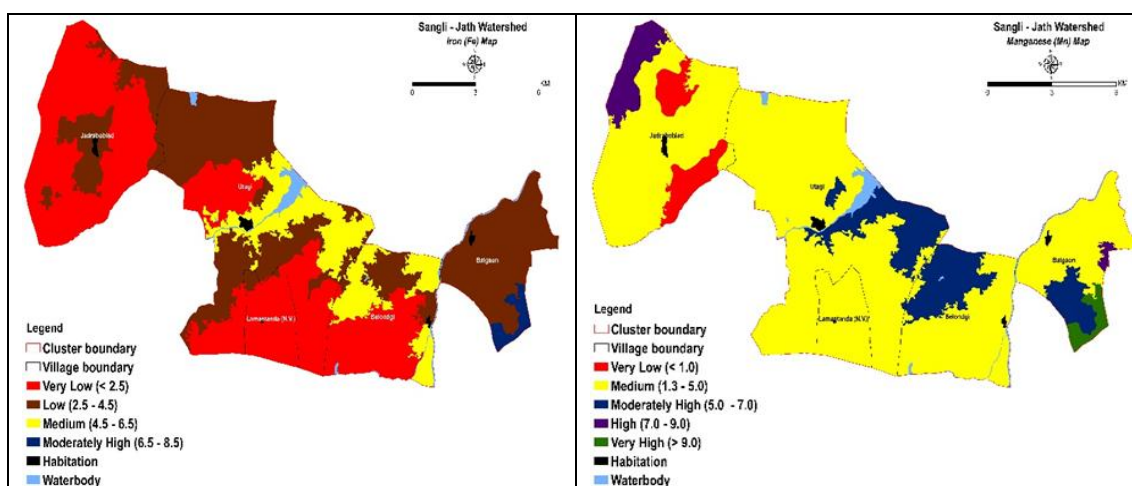


Fig. 4.16: DTPA-extractable soil Fe map of Sangli-Jath watershed

Fig. 4.17: DTPA-extractable soil Mn map of Sangli-Jath watershed

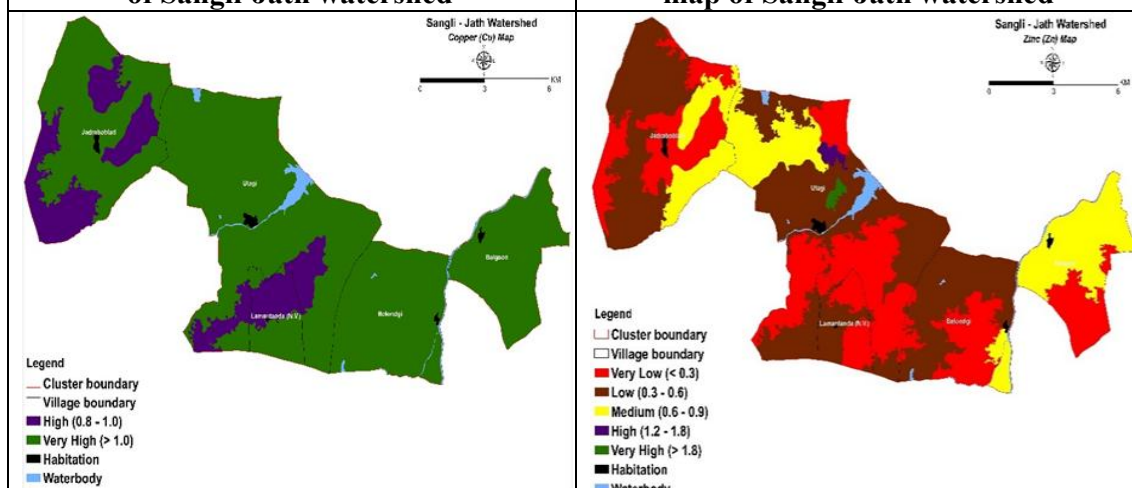


Fig. 4.18: DTPA-extractable soil Cu map of Sangli-Jath watershed

Fig. 4.19: DTPA-extractable soil Zn map of Sangli-Jath watershed

4.6 Surface Runoff

Surface runoff estimation for the cluster watershed in Jath Taluka, Sangli District, provides important insight into the hydrological response of the landscape to seasonal monsoon rainfall. In semi-arid environments, a substantial portion of precipitation is

typically lost through infiltration, soil moisture storage, and evapotranspiration, while only a relatively small fraction contributes to surface runoff. Although limited in magnitude, runoff plays a critical role in redistributing water across the landscape, transporting sediments, and contributing to localized groundwater recharge through drainage pathways.

To evaluate the hydrological behaviour of the watershed, historical rainfall and derived runoff data for the period 2014–2024 were analysed to assess both temporal and seasonal variability in runoff generation. While rainfall represents the total atmospheric water input to the watershed, it does not directly indicate the amount of water that becomes surface runoff. Estimating runoff depths from observed rainfall therefore provides a more realistic representation of the effective water available for surface flow processes. Such information is essential for identifying suitable locations and capacities for rainwater harvesting structures, soil and water conservation measures, and integrated watershed management interventions.

The monthly analysis indicates that surface runoff in the Jath cluster watershed remains relatively low throughout the monsoon season. During the early monsoon months of June and July, much of the rainfall is absorbed by dry soils and vegetation cover, resulting in minimal runoff generation. Even during August, when rainfall intensity generally increases, average runoff rarely exceeds 7 mm. The highest runoff values are observed in September and October, yet the monthly averages generally remain below 20 mm. These observations suggest that the watershed exhibits limited runoff response, with most rainfall being retained within the soil profile or stored temporarily as soil moisture.

Inter-annual variability in runoff is also relatively modest. In most years, the estimated annual runoff depth remains below 70 mm, despite fluctuations in total rainfall. Slightly higher runoff values observed in years such as 2016, 2017, and 2019 appear to be associated with localized high-intensity rainfall events, which temporarily exceed the infiltration capacity of soils and generate short-duration overland flow.

From a hydrological perspective, the consistently low magnitude of both monthly and annual runoff indicates low runoff coefficients and high infiltration potential within the watershed. Consequently, a large proportion of precipitation contributes to soil moisture replenishment and potential groundwater recharge rather than sustained surface flow. This behaviour is characteristic of semi-arid catchments, where rainfall intensity, antecedent soil moisture conditions, and soil infiltration capacity strongly control runoff generation.

The results therefore highlight the importance of enhancing groundwater recharge and promoting decentralized rainwater harvesting structures such as farm ponds, percolation tanks, and check dams. Management strategies that improve in situ moisture conservation and subsurface storage are likely to be more effective than those relying primarily on direct surface runoff capture. Overall, the hydrological response observed in the Jath watershed is consistent with typical semi-arid landscapes, where infiltration-dominated processes govern water balance dynamics and surface runoff remains limited.

Table 4.25 presents the monthly rainfall and runoff (June–October) for the period 2014–2024, confirming that runoff values never exceed 20 mm. Fig. 4.20 illustrates the

monthly distribution of rainfall and runoff, showing the dominance of September and October in minimal runoff production and the negligible contribution of early monsoon months.

Table 4.25 Details of Monthly (June-Oct) runoff (mm) for the period 2014-2024

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	35.9	0.0	84.2	0.2	158.4	22.5	27.4	0.0	34.5	0.0
2015	49.9	0.4	14.5	0.0	110.0	0.4	119.7	1.0	24.2	0.0
2016	81.0	0.0	96.2	0.0	29.7	0.0	215.7	48.4	63.7	0.5
2017	143.4	6.2	30.1	0.0	129.8	9.7	179.9	10.2	135.2	29.8
2018	61.6	0.0	23.4	0.0	87.1	0.0	80.0	0.3	11.0	0.0
2019	114.4	1.4	50.1	0.0	42.1	0.0	169.3	28.5	184.6	39.2
2020	152.2	5.6	151.0	0.9	72.1	0.0	148.5	0.3	154.1	39.2
2021	135.0	6.4	175.2	21.7	124.3	2.8	116.6	0.1	36.4	0.0
2022	129.2	0.7	195.3	5.3	117.7	26.5	103.5	7.2	189.3	19.0
2023	59.6	0.0	160.3	14.8	35.7	0.0	79.9	0.0	5.4	0.0
2024	156.8	14.9	72.6	0.0	149.2	19.6	119.5	2.7	68.6	0.9
Average	101.7	3.2	95.7	3.9	96.0	7.4	123.6	9.0	82.5	11.7

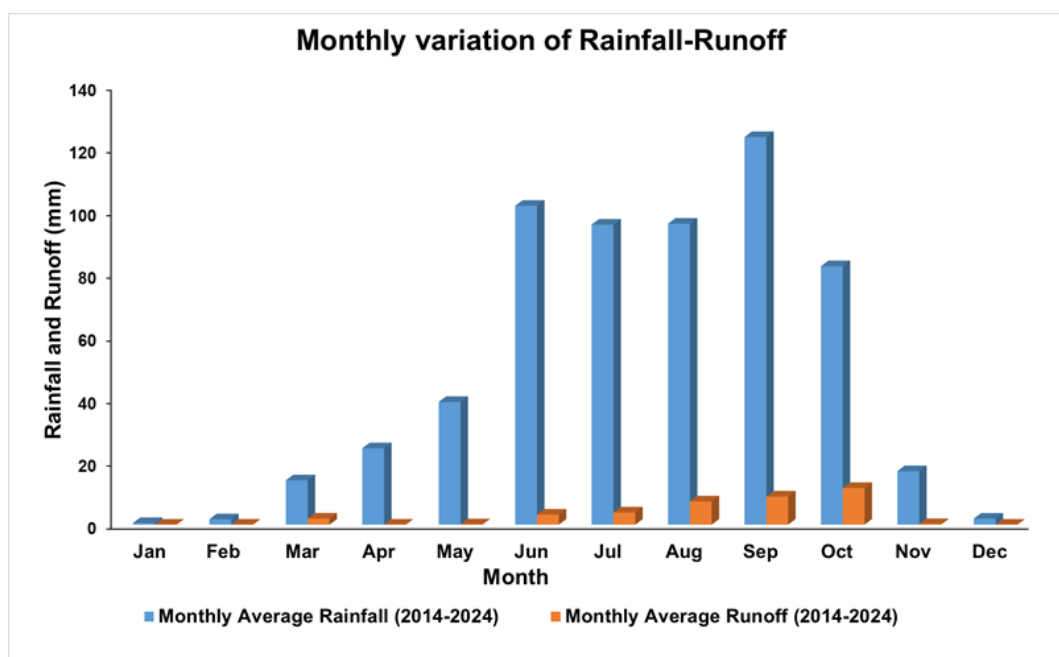


Fig 4.20: Monthly variation of rainfall-runoff in Jath watershed

Table 4.26. Relationship between rainfall and runoff

Year	Rainfall (mm)	Runoff (mm)	No. of Runoff Events	Runoff (%)
2014	560.1	44.1	6	7.9
2015	389.5	1.7	4	0.4
2016	519.9	48.8	6	9.4
2017	645.1	55.8	11	8.7
2018	367.5	1.3	2	0.4
2019	610.6	69.1	13	11.3
2020	787.0	46.0	8	5.8
2021	721.1	31.1	11	4.3
2022	821.8	58.7	12	7.1
2023	485.3	16.4	6	3.4
2024	674.8	38.8	12	5.7
Average	598	37	8	6

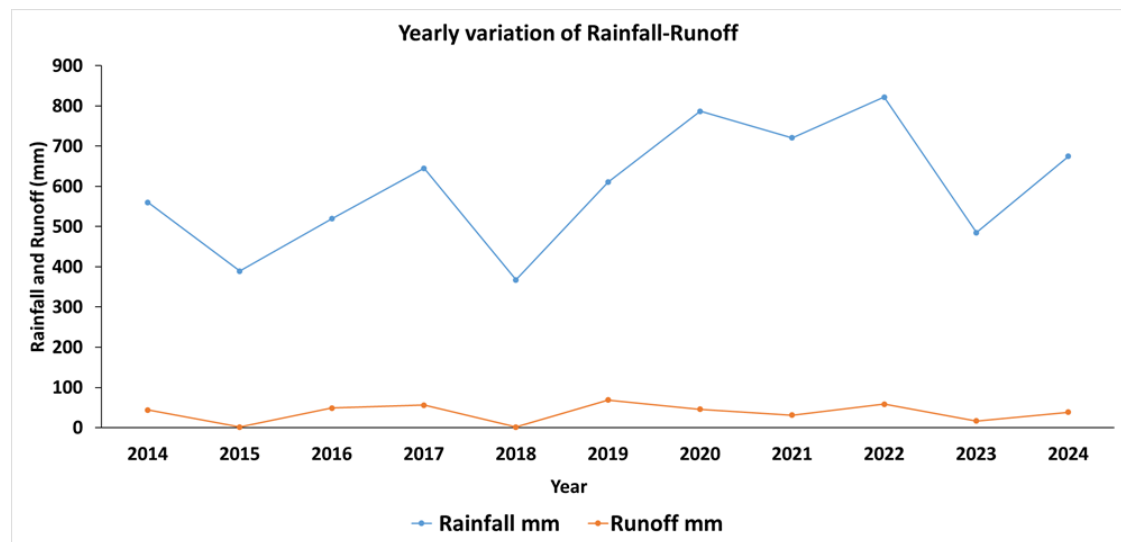


Fig 4.21: Yearly variation of rainfall-runoff in Jath watershed

The annual rainfall–runoff relationship is summarized in Table 4.26, which presents total annual rainfall, estimated runoff depth, number of runoff-generating events, and runoff percentage. The analysis indicates that the average annual runoff depth is

approximately 37 mm, which represents about 6% of the mean annual rainfall of 598 mm. This relatively low runoff coefficient suggests that a large proportion of precipitation is retained within the watershed through infiltration, soil moisture storage, and evapotranspiration rather than being converted into surface flow.

The interannual variability in rainfall and runoff is illustrated in Fig. 4.21, which shows that runoff remains consistently low across years despite fluctuations in total rainfall. This pattern indicates that the watershed exhibits limited surface runoff response, with runoff generation occurring primarily during occasional high-intensity rainfall events when rainfall temporarily exceeds the soil infiltration capacity.

The hydrological behaviour of the Jath cluster watershed is characterized by low runoff efficiency and high infiltration potential. Early monsoon rainfall is largely absorbed by dry soils, contributing mainly to soil moisture replenishment, while late-season rainfall produces relatively small amounts of overland flow. The average runoff proportion of approximately 6% of annual rainfall confirms that the watershed functions as an infiltration-dominated catchment with limited capacity for sustained surface flow. These findings suggest that water resource management strategies should prioritize groundwater recharge, in situ moisture conservation, and decentralized rainwater harvesting structures such as farm ponds, check dams, and percolation tanks. Planning interventions based on this hydrological behaviour ensures that watershed management strategies remain aligned with the inherent rainfall–runoff characteristics and water balance dynamics of the region.

4.7 Mapping of Groundwater Potential Zones

Groundwater represents the most reliable source of water in semi-arid regions where surface water availability is limited and highly seasonal. In Jath Taluka of Sangli District, Maharashtra, groundwater supports agricultural irrigation, domestic consumption, and livestock requirements. However, the region receives an average annual rainfall of approximately 598 mm, which is concentrated within a short monsoon period. Such rainfall patterns, combined with high evapotranspiration and limited recharge opportunities, often result in declining groundwater levels and periodic water scarcity. Under these conditions, the identification and mapping of Groundwater Potential Zones (GWPZ) are essential for sustainable groundwater resource management.

The present study was conducted within a five-village cluster watershed in Jath Taluka. Groundwater potential zones were delineated using a GIS-based multi-criteria decision analysis approach integrating eight thematic parameters that influence groundwater occurrence and recharge conditions. These parameters include lithology, elevation, land use/land cover (LULC), landform, soil texture, slope, rainfall, and drainage density. Each parameter was prepared as a thematic layer in a GIS environment and subsequently standardized and assigned weights using the Analytical Hierarchy Process (AHP) based on their relative influence on groundwater recharge and storage. The weighted thematic layers were then integrated using a weighted overlay analysis to generate a spatial map of groundwater potential zones.

The lithology of the study area is dominated by basaltic formations of the Deccan Traps, where groundwater occurrence is largely controlled by weathered and fractured zones. Massive basalt layers generally exhibit low primary porosity and restrict groundwater movement, whereas fractured and weathered horizons provide localized storage and transmissivity. Elevation within the watershed ranges from 473 to 583 m above mean sea level, and the terrain is characterized by gently undulating topography. Slope conditions influence infiltration and runoff processes, with relatively flatter areas favouring groundwater recharge. Land use is primarily dominated by rainfed agriculture, including crops such as jowar, bajra, and pulses, with limited horticultural patches. Soil texture and drainage characteristics further influence infiltration capacity, while rainfall distribution determines the overall recharge potential within the watershed.

Based on the integrated analysis, the watershed was classified into five groundwater potential categories: Very Poor, Poor, Moderate, Good, and Very Good. The results indicate that 15.2% of the watershed area falls under the Very Poor category, followed by 33.8% under Poor, 29.7% under Moderate, 18.7% under Good, and 2.7% under Very Good groundwater potential zones. The spatial distribution shows that a large proportion of the watershed is dominated by Poor to Moderate groundwater potential, which together account for more than 63% of the total area. Nearly 49% of the watershed falls under the combined Very Poor and Poor categories, indicating generally limited groundwater recharge conditions across a significant portion of the landscape. Areas categorized as Good and Very Good potential zones occupy relatively smaller extents and are typically associated with favourable combinations of gentle slopes, permeable soils, and drainage conditions that support groundwater recharge.

The spatial distribution of groundwater potential zones reflects the hydrogeological characteristics of the semi-arid basaltic terrain of the Deccan Plateau, where groundwater occurrence is largely controlled by secondary porosity in weathered and fractured basalt layers. The predominance of Poor to Moderate potential zones indicates that groundwater availability is constrained by both lithological conditions and limited recharge opportunities.

The delineation of groundwater potential zones provides a scientific basis for prioritizing groundwater recharge interventions and water resource planning within the watershed. Areas identified as Good and Very Good potential zones may be suitable for groundwater development and recharge structures such as percolation tanks, check dams, and recharge shafts, while regions categorized as Poor or Very Poor require soil and water conservation measures, in situ moisture conservation, and careful regulation of groundwater extraction. The integration of GIS and multi-criteria analysis thus provides a robust framework for supporting sustainable groundwater management and watershed planning in Jath Taluka.

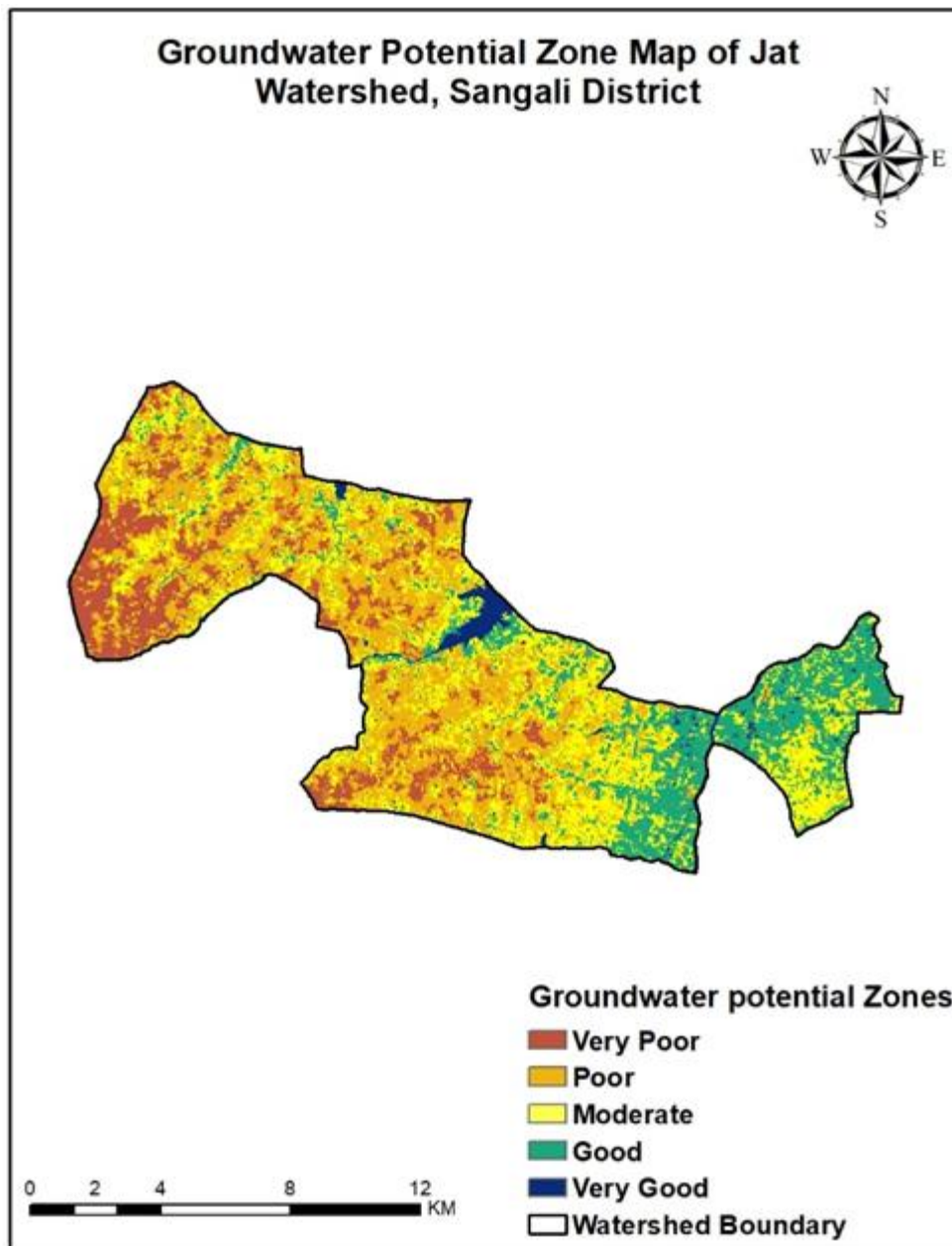


Fig. 4.22. Ground water potential zones in Jath watershed

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), which is 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 Wheat Cultivation

The soil site suitability carried out for the wheat crop is presented in Table 4.27 and figure 4.23. It suggests that wheat is highly suitable (S1) for cultivation in 2331 ha (16.4%) of the cluster, as this region has favorable temperature and rainfall for cultivation. Moderately suitable area for cultivation is 1199.2 ha (8.4%). This area is constrained by land having a gentle slope and shallow soil. A major proportion of the cluster is marginally suitable (S3) with an area of 7714 ha (54.2%). This area is characterized by low organic content, which can be addressed by applying farmyard manure. Not suitable (N) land for cultivation of 2710.7 ha (19.0%) has shallow soil with coarse fragments.

Table 4.27 Area under suitability sub-classes for Wheat cultivation

Sr. No.	Suitability classes	Area (ha)	Percent (%)
1	Highly Suitable (S1)	2331.9	16.4
2	Moderately Suitable (S2)	1199.2	8.4
3	Marginally Suitable (S3)	7713.9	54.2
4	Not Suitable (N)	2710.7	19.0
5	Habitation	62.2	0.4
6	Waterbody	220.1	1.6
Total		14237.9	100.0

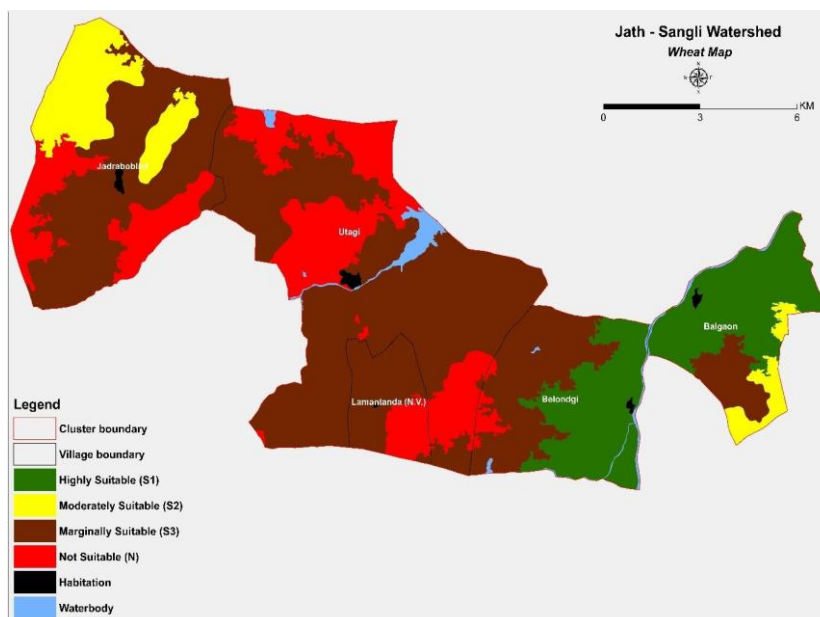


Fig. 4.23 Soil site suitability map for Wheat cultivation

4.8.2 Area under suitability sub-classes for Maize Cultivation

Only 11.7% of the watershed area was found to be highly suitable(S1) and 8.3% moderately suitable(S2) for maize, providing optimal manageable conditions for crop growth and productivity. Almost half of the watershed was marginally suitable for maize. Maize crop, indicating moderate to severe soil, terrain and environmental constraints limiting crop productivity. An additional 22.2% of the area is not suitable (N) for the crop, suggesting that maize may be cultivated by strictly following the recommended package of practices in Jath watershed (Table 4.28, Fig. 4.24).

Table 4.28 Area under suitability sub-classes for Maize cultivation

Sr.No.	Suitability classes	Area (ha)	Percent (%)
1	Highly Suitable (S1)	1658.2	11.7
2	Moderately Suitable (S2)	1181.0	8.3
3	Marginally Suitable (S3)	7952.6	55.9
4	Not Suitable (N)	3163.9	22.2
5	Habitation	62.2	0.4
6	Waterbody	220.1	1.6
Total		14237.9	100.0

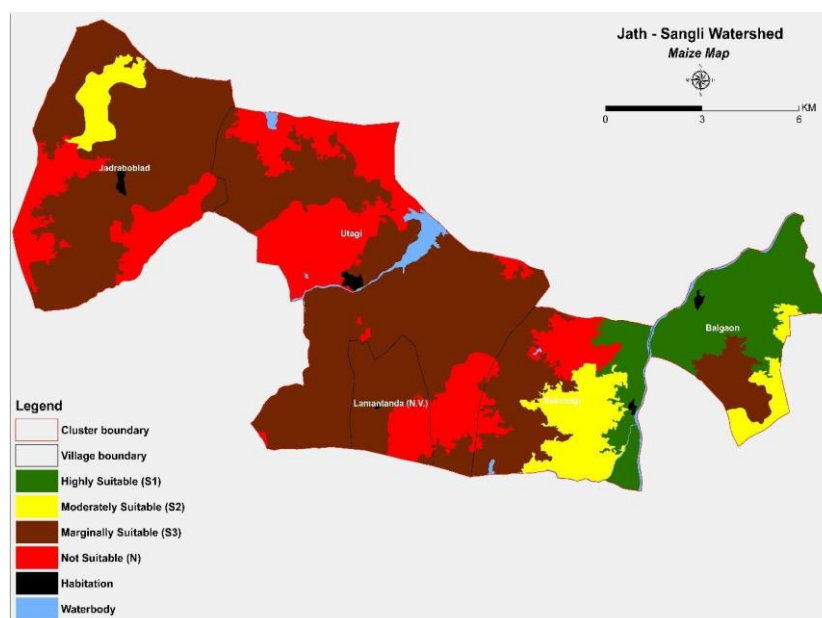


Fig. 4.24 Soil site suitability map for Maize cultivation

4.8.3 Soil-Site Suitability for Sorghum (Jowar) Cultivation

The soils of the watershed were evaluated for sorghum cultivation based on crop-specific requirements. The distribution of suitability classes is presented in Table 4.29. The results indicate that about 12% of the watershed area provides favorable soil and site conditions for optimal crop growth and is highly suitable (S1) for sorghum due to adequate soil texture, depth and drainage. The moderately suitable (S2) category covers 458 ha, wherein minor soil and environmental constraints may reduce crop productivity. Around 65.0% of the watershed was found to be marginally suitable (S3) for the crop, reflecting moderate to severe limitations related to soil and terrain parameters that may restrict yield potential unless appropriate agronomic management practices are adopted.

Furthermore, one-fifth of the watershed area is not suitable (N) for sorghum cultivation due to severe soil and site constraints. Therefore, it is suggested that, sorghum is water management interventions may be adopted (Fig. 4.25).

Table 4.29 Area under different suitability sub-classes for Sorghum cultivation

Sr.No.	Suitability classes	Area (Ha)	Percent (%)
1	Highly Suitable (S1)	1707.3	12.0
2	Moderately Suitable (S2)	458.2	3.2
3	Marginally Suitable (S3)	9259.2	65.0
4	Not Suitable (N)	2531.0	17.8
5	Habitation	62.2	0.4
6	Waterbody	220.1	1.6
Total		14237.9	100.0

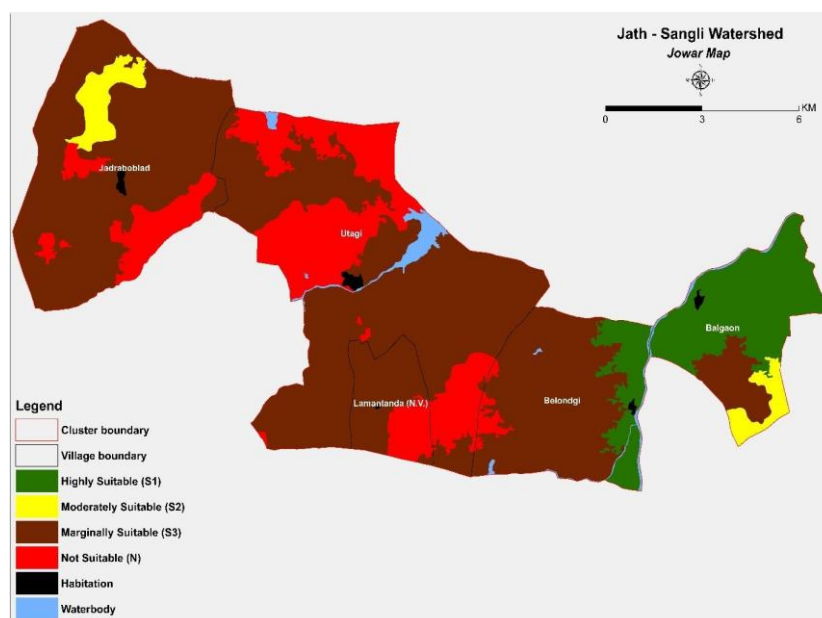


Fig. 4.25 Soil site suitability map for Sorghum (Jowar) cultivation

4.8.4 Soil-Site Suitability for Pearl millet (Bajra) Cultivation

11.6% of the watershed area were categorized under highly suitable (S1) due to good drainage capacity, pH and 7% moderately suitable(S2), respectively for pearl millet cultivation, whereas 11296.1 ha (79.3%) of area was found to be marginally suitable (S3), reflecting moderate to severe constraints primarily associated with stony soil, slope, moisture retention which may restrict yield potential without appropriate management practices semi-arid reason. Pearl millet is recommended in around whole of the watershed (Table 4.30, Fig. 4.26)

Table 4.30 Area under suitability sub-classes for Pearl millet (Bajra) cultivation

Sr.No.	Suitability classes	Area (Ha)	Percent (%)
1	Highly Suitable (S1)	1658.1	11.6
2	Moderately Suitable (S2)	1001.3	7.0
3	Marginally Suitable (S3)	11296.1	79.3
4	Habitation	62.1	0.4
5	Waterbody	220.0	1.5
Total		14237.86	100.00

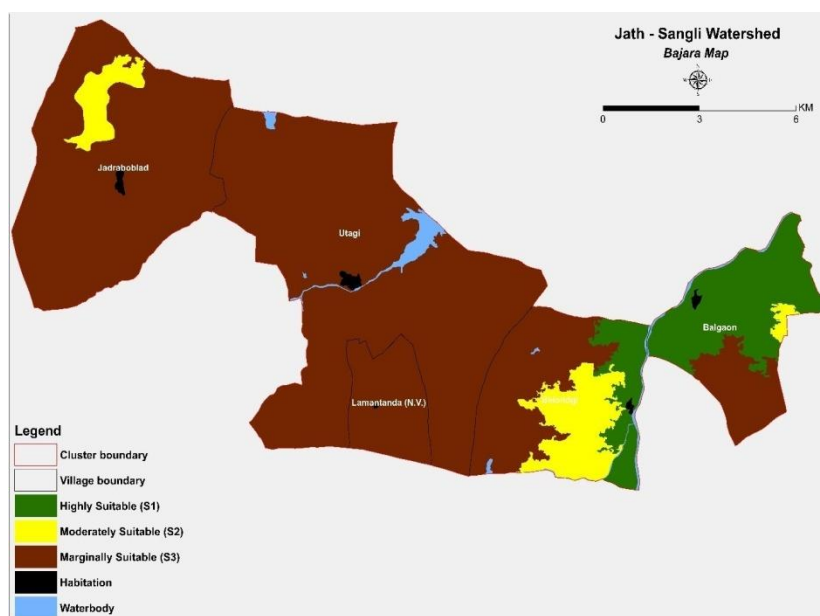


Fig. 4.26 Soil site suitability map for Pearl millet(Bajra) cultivation

4.8.5 Soil-Site Suitability for Gram Cultivation

Soil site suitability evaluation for gram suggests that 7714 ha (54.1%) of land is marginally suitable (S3) for cultivation of gram, as shown in Table 4.31 and figure 4.27. This region is limiting crop growth due to inadequate soil depth. About 2331.8 ha (16.3%) of land is highly suitable (S1), as this region has an optimal climate for growth. Nearly one-fifth of the land, 2710.6 ha (19.0%), is not suitable (N) for cultivation due to coarse fragments in the soil. Nearly 1199 ha (8.4%) of land is moderately suitable (S2) for cultivation. The soils in this region have lower organic carbon content, which can be mitigated by applying farmyard manure.

Table 4.31 Area under suitability sub-classes for Gram cultivation

Sr.No.	Suitability classes	Area (Ha)	Percent (%)
1	Highly Suitable (S1)	2331.8	16.3
2	Moderately Suitable (S2)	1199.1	8.4
3	Marginally Suitable (S3)	7713.9	54.1
4	Not Suitable (N)	2710.6	19.0
5	Habitation	62.1	0.4
6	Waterbody	220.0	1.5
Total		14237.8	100

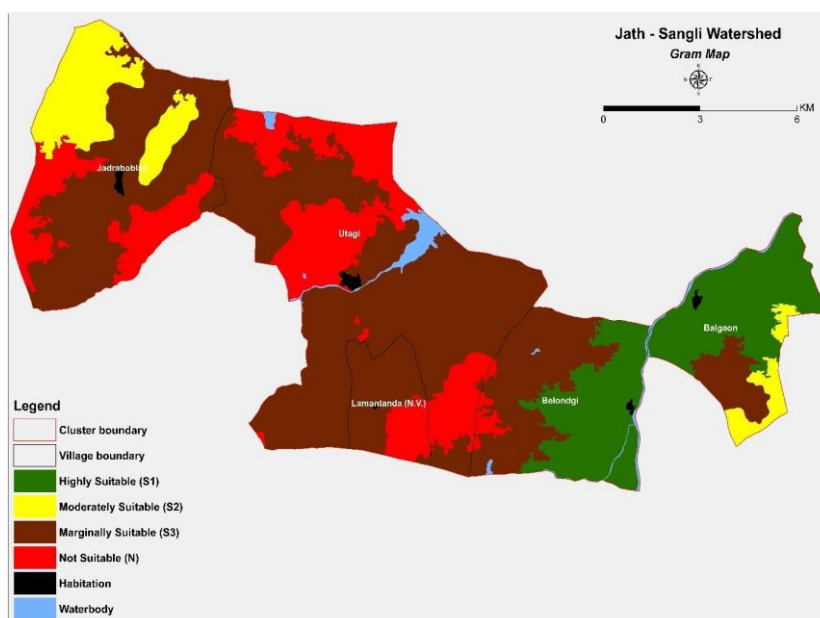


Fig. 4.27 Soil site suitability map for Gram cultivation

4.8.6 Soil-Site Suitability for Pigeon pea Cultivation

The soil-site suitability analysis indicates that the regional rainfall is sufficient for pigeon pea cultivation. However, the land suitability varies significantly: 1658 ha (11.6%) is considered Highly Suitable (S1), 674 ha (4.7%) is Moderately Suitable (S2), and a larger area of 3856 ha (27.0%) is only Marginally Suitable (S3). About 7767 ha (54.5%) is determined to be Not Suitable for cultivation, with the presence of shallow soil being identified as a key limiting factor influencing these suitability classifications (Table 4.32, Fig. 4.28).

Table 4.32 Area under suitability sub-classes for Pigeon pea cultivation

Sr.No.	Suitability classes	Area (Ha)	Percent (%)
1	Highly Suitable (S1)	1658.1	11.6
2	Moderately Suitable (S2)	673.7	4.7
3	Marginally Suitable (S3)	3856.6	27.0
4	Not Suitable (N)	7767.1	54.5
5	Habitation	62.1	0.4
6	Waterbody	220.0	1.5
Total		14237.86	100.00

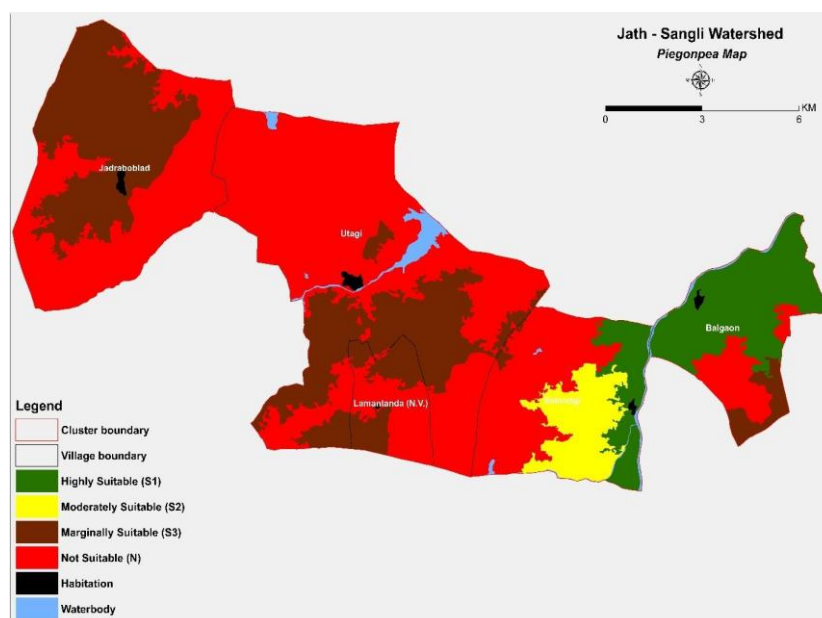


Fig. 4.28 Soil site suitability map for Pigeon pea cultivation

4.8.7 Soil-Site Suitability for Soybean Cultivation

Soil-site evaluation results for soybeans show a varied distribution of suitability classes across the watershed (Table 4.33, Fig. 4.29). Areas categorized as highly suitable (S1) cover 1658.1 ha, accounting for about 11.6% of the total geographical area, indicating favorable soil and site conditions for achieving good crop performance. An additional 7.0% of the area is occupied under moderately suitable (S2) class, representing zones where soybean cultivation is feasible, although certain soil or site constraints may influence yield levels. The marginally suitable (S3) category extends over 7039.1 ha, accounting for about 49.4%, suggesting the presence of noticeable limitations that may restrict optimum crop growth. About one-third of the watershed is not suitable (N) for soybean cultivation due to stony soil in depth. These results mostly favour soybean cultivation in the watershed by following the recommended package of practices.

Table 4.33 Area under suitability sub-classes for Soybean cultivation

Sr.No.	Suitability classes	Area (ha)	Percent (%)
1	Highly Suitable (S1)	1658.1	11.6
2	Moderately Suitable (S2)	1001.3	7.0
3	Marginally Suitable (S3)	7039.1	49.4
4	Not Suitable (N)	4256.9	29.9
5	Habitation	62.1	0.4
6	Waterbody	220.0	1.5
Total		14237.8	100.0

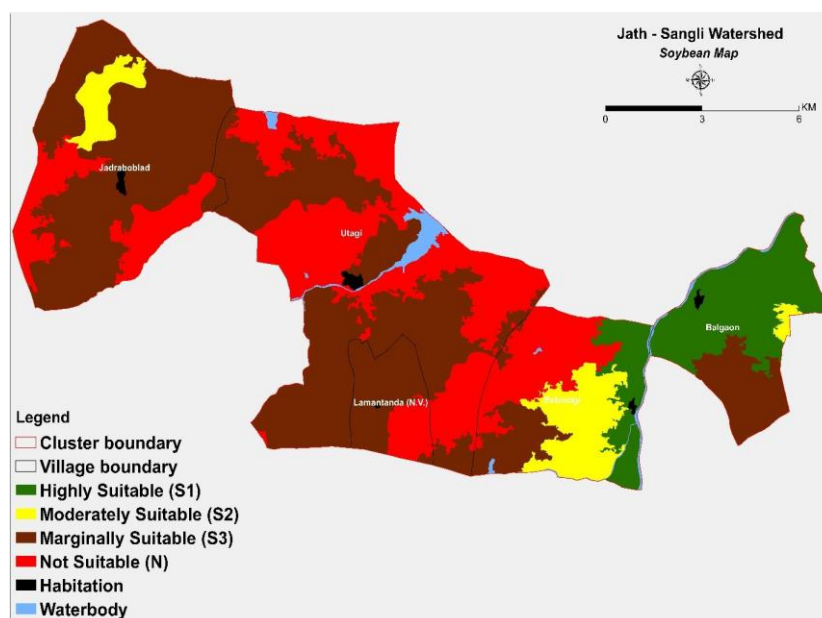


Fig. 4.29 Soil site suitability map for Soybean cultivation

4.8.8 Soil-Site Suitability for Cotton Cultivation

The soil-site evaluation for cotton cultivation shows that 1658.16 ha (11.6%) of the total geographical area is classified as highly suitable (S1), these areas provide favorable conditions for cotton cultivation due to proper drainage, salinity, good soil depth and suitable soil texture. Only 722.8 ha (5.0%) area is moderately suitable.

A large portion of the watershed, covering 8086.3 ha (56.7%), falls under the marginally suitable (S3) category (Table 4.34, Fig. 4.30), indicating the presence of moderate limitations that may restrict yield potential just like moderate slope, low organic carbon and shallow soil depth. Additionally, 3488.2 ha (24.5%) of the area is categorized as not suitable (N) for cotton cultivation due to severe soil and site-related constraints. Overall, the assessment indicates that nearly one fourth of the watershed is unsuitable for cotton cultivation, while about half of the area exhibits marginally suitability.

Table 4.34 Area under suitability sub-classes for Cotton cultivation

Sr.No.	Suitability classes	Area (ha)	Percent (%)
1	Highly Suitable (S1)	1658.1	11.6
2	Moderately Suitable (S2)	722.8	5.0
3	Marginally Suitable (S3)	8086.3	56.7
4	Not Suitable (N)	3488.2	24.5
5	Habitation	62.1	0.4
6	Waterbody	220.0	1.5
Total		14237.8	100.0

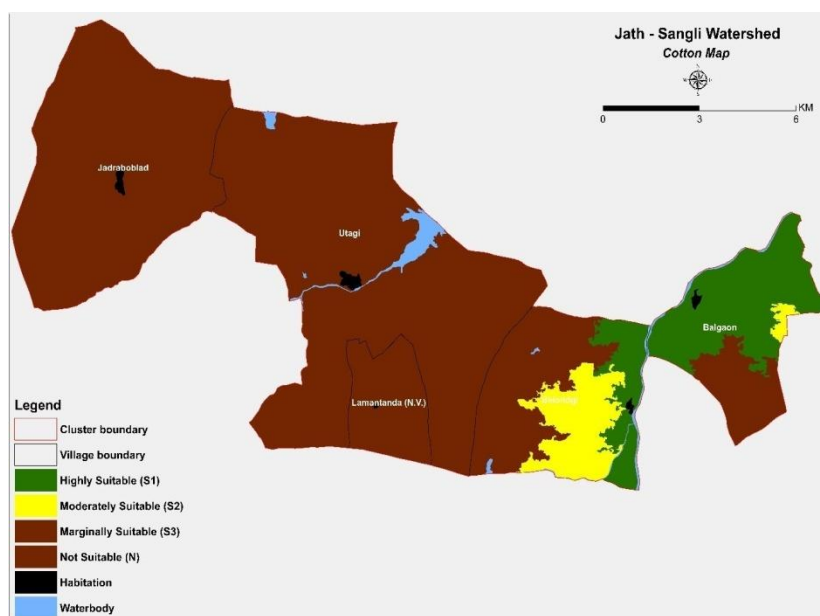


Fig. 4.30 Soil site suitability map for Cotton cultivation

4.8.9 Soil-Site Suitability for Chilli Cultivation

The soil site suitability assessment indicates that this region has favorable temperatures for the growth of chili but lacks sufficient rainfall to meet its crop water requirement. Nearly half of the area, 7714 ha (54.1%), is marginally suitable (S3) as shown in Table 4.35 and figure 4.31. Effective irrigation practices that prioritize water conservation are essential for successful crop cultivation. About 1199.1 ha (8.4%) of land is moderately suitable (S2) for cultivation. Leveling the land and applying farmyard manure will improve the cultivation. Nearly one-fifth of the land, 2710 ha (19.0%), is not suitable for cultivation. This region has shallow soil with coarse fragments. The remaining 2331.8 ha (16.3%) is highly suitable for cultivation.

Table 4.35 Area under suitability sub-classes for Chilli cultivation

Sr.No.	Suitability classes	Area (ha)	Percent (%)
1	Highly Suitable (S1)	2331.8	16.3
2	Moderately Suitable (S2)	1199.1	8.4
3	Marginally Suitable (S3)	7713.9	54.1
4	Not Suitable (N)	2710.6	19.0
5	Habitation	62.1	0.4
6	Waterbody	220.0	1.5
Total		14237.8	100.0

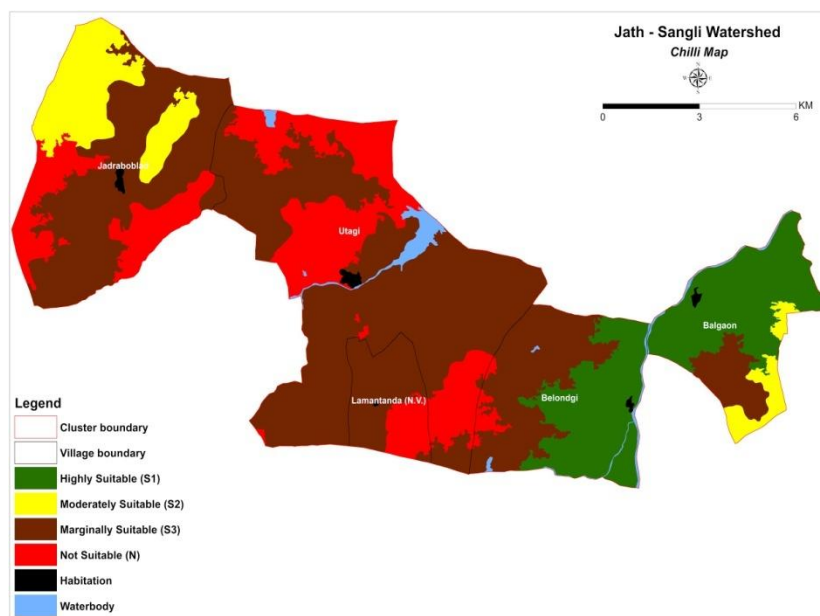


Fig. 4.31 Soil site suitability map for Chilli cultivation

4.8.10 Soil-Site Suitability for Sugarcane Cultivation

The soils of the watershed were evaluated for their suitability for sugarcane cultivation based on crop-specific requirements. The spatial distribution of suitability classes is presented in Table 4.36 and the corresponding map in Fig. 4.32. The results indicate that 1658.1 ha (11.6%) of the total geographical area (TGA) is classified as highly suitable (S1), reflecting favorable soil depth, texture, drainage, fertility status, and terrain conditions for optimum sugarcane growth and productivity. Moderately suitable (S2) areas extend over 673.7 ha (4.7%), where certain manageable limitations related to soil depth, drainage, or fertility may slightly restrict yield potential.

A relatively smaller proportion of the watershed, covering 458.1 ha (3.2%), falls under the marginally suitable (S3) class, indicating the presence of moderate to severe soil and site constraints that may significantly affect crop performance unless appropriate soil and water management practices are adopted. Conversely, the majority of the watershed, accounting for over 78% (11,165 ha), is classified as not suitable (N) for sugarcane cultivation. The detailed evaluation of soil-site parameters indicates that this unsuitability is primarily driven by severe climatic and physical constraints, specifically inadequate rainfall and unfavorable Length of Growing Period (LGP), alongside significant limitations in soil depth across various soil units.

Table 4.36 Area under suitability sub-classes for Sugarcane cultivation

Sr.No.	Suitability classes	Area (ha)	Percent (%)
1	Highly Suitable (S1)	1658.1	11.6
2	Moderately Suitable (S2)	673.7	4.7
3	Marginally Suitable (S3)	458.1	3.2
4	Not Suitable (N)	11165.6	78.4
5	Habitation	62.1	0.4
6	Waterbody	220.0	1.5
Total		14237.8	100.0

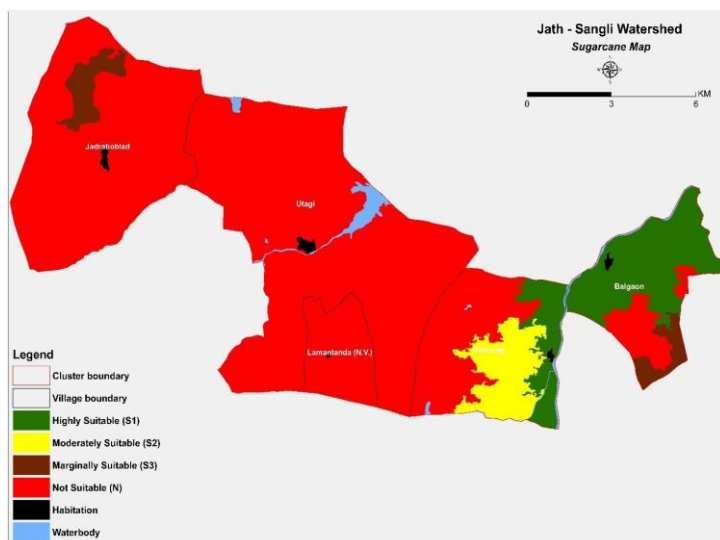


Fig. 4.32 Soil site suitability map for Sugarcane cultivation

4.8.11 Soil-Site Suitability for Grapes Cultivation

The spatial distribution of suitability classes in respect of grapes is presented in Table 4.37 and Fig. 4.33 indicate that about 4323 ha (30.3%) of the watershed area is either moderately (S2) or marginally (S3) suitable category, suggesting that grapes could be cultivated with caution in limited portions of the watershed.

Table 4.37 Area under suitability sub-classes for Grape cultivation

Sr.No.	Suitability classes	Area (ha)	Percent (%)
1	Highly Suitable (S1)	1658.1	11.6
2	Marginally Suitable (S3)	4323.0	30.3
3	Not Suitable (N)	7974.5	56.0
4	Habitation	62.1	0.4
5	Waterbody	220.0	1.5
Total		14237.8	100.0

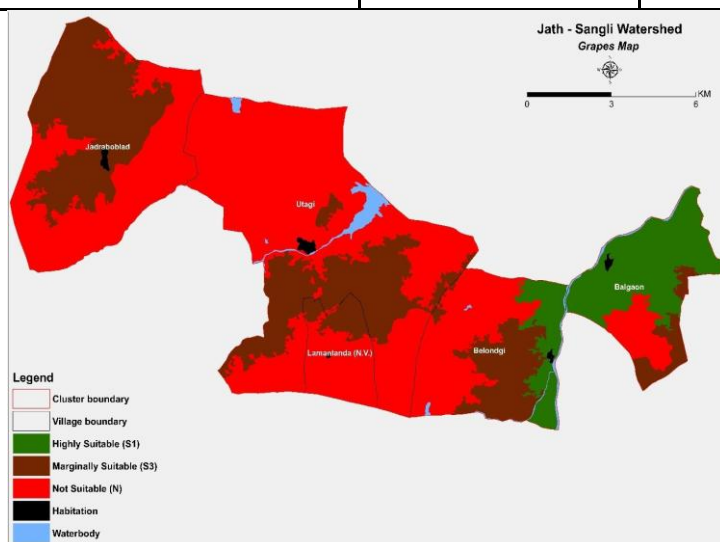


Fig. 4.33 Soil site suitability map for Grapes cultivation

4.8.12 Soil-Site Suitability for Lemon Cultivation

The soils of the watershed were evaluated for Lemon cultivation based on crop-specific requirements. The distribution of suitability classes is presented in Table 4.38 and Fig. 4.34. The results indicate that 1658.1 ha (11.6% of the total geographical area of the watershed) is classified as highly suitable (S1), providing favorable conditions for lemon growth and productivity. A considerable portion of the watershed (around one-third of the area) is categorized as marginally suitable (S3), reflecting moderate to severe constraints related to soil properties and terrain slope, which may restrict yield potential unless appropriate management practices are adopted.

About 46.1% of the watershed area is not suitable (N) for Lemon cultivation due to severe limitations associated with rocky soil, topography, waterlogging, steep slope and alkalinity of soil. Overall, the evaluation suggests that while limited soil is suitable for lemon cultivation.

Table 4.38 Area under suitability sub-classes for Lemon cultivation

Sr.No.	Suitability classes	Area (Ha)	Percent (%)
1	Highly Suitable (S1)	1658.1	11.6
2	Moderately Suitable (S2)	722.8	5.0
3	Marginally Suitable (S3)	5003.1	35.1
4	Not Suitable (N)	6571.5	46.1
5	Habitation	62.1	0.4
6	Waterbody	220.0	1.5
Total		14237.86	100.00

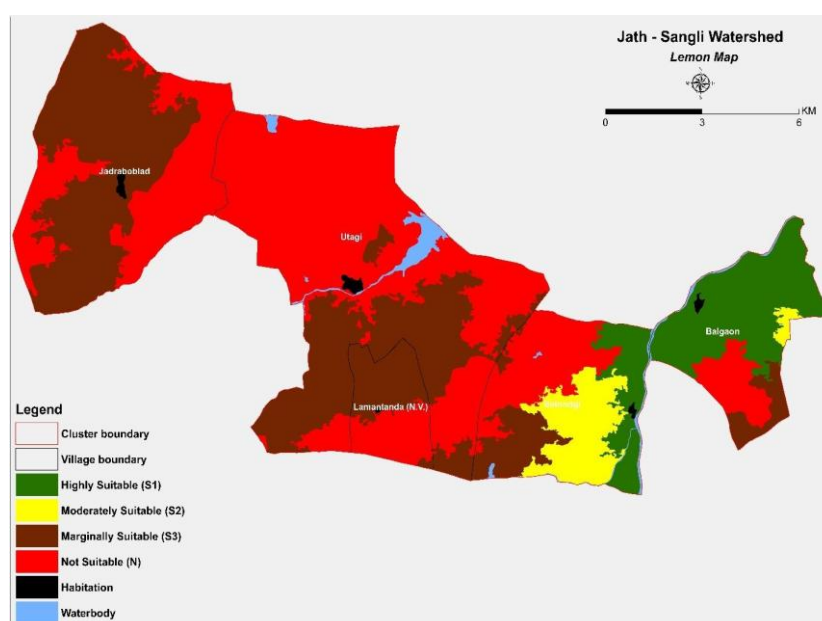


Fig. 4.34 Soil site suitability map for Lemon cultivation

4.8.13 Soil-Site Suitability for Papaya Cultivation

Soil site suitability for papaya was assessed based on its crop specific requirements. The areal distribution of suitability classes is presented in Table 4.39 and Fig. 4.35. The assessment indicates a major portion of the total geographic area (TGA), 78%, is not suitable (N). These areas are constrained due to insufficient rainfall, shallow soil depth, and the presence of hardpan in most of the region.

About 8% (1181 ha) of the area is marginally suitable (S3). In these regions, limitations such as moderate soil depth and suboptimal pH reduce the overall suitability. Nearly 1% (187.8 ha) of the area is moderately suitable (S2), while 10.3% (1470 ha) of the area is highly suitable (S1).

Table 4.39 Area under suitability sub-classes for Papaya cultivation

Sr.No.	Suitability classes	Area (ha)	Percent (%)
1	Highly Suitable (S1)	1470.3	10.3
2	Moderately Suitable (S2)	187.8	1.3
3	Marginally Suitable (S3)	1181.02	8.29
4	Not Suitable (N)	11116.48	78.08
5	Habitation	62.15	0.44
6	Waterbody	220.05	1.55
Total		14237.86	100

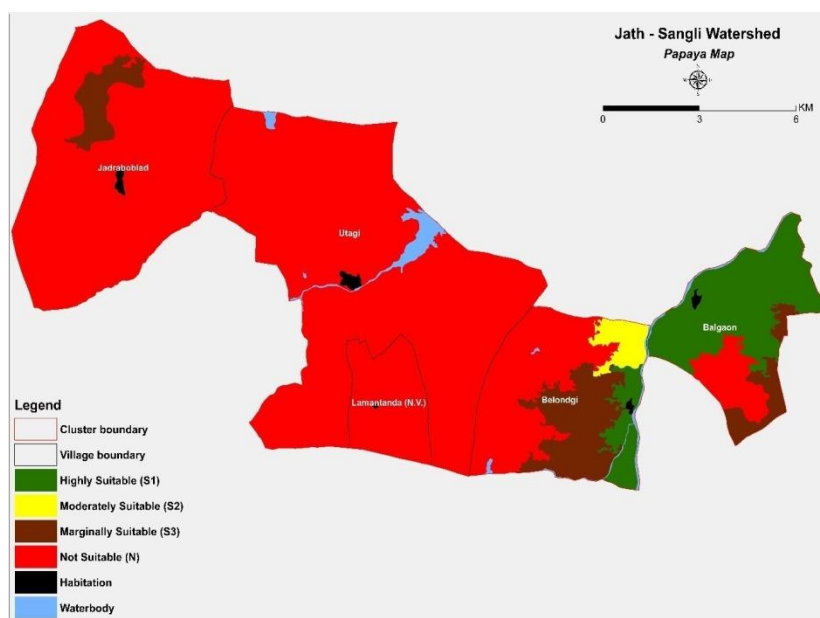


Fig. 4.35 Soil site suitability map for Papaya cultivation

4.8.14 Soil-Site Suitability for Guava Cultivation

The soils of the watershed were evaluated for Guava cultivation based on crop-specific requirements. The distribution of suitability classes is presented in Table 4.40 and Fig. 4.36. The results indicate that 1658.1 ha (11.6% of the total geographical area of the watershed) is classified as highly suitable (S1), providing favorable conditions for guava

growth and productivity due to loamy texture. 34.3% of area is marginally suitable (S3), reflecting moderate to severe constraints, which may restrict yield potential unless appropriate management practices and conservation measures possible.

More than 45% of the watershed area is not suitable (N) for guava cultivation due to severe limitations associated with stony soil, topography, and shallow soil. Overall, the evaluation suggests that while nearly one-tenth of the watershed is highly suitable for guava cultivation.

Table 4.40 Area under suitability sub-classes for Guava cultivation

Sr.No.	Suitability classes	Area (ha)	Percent (%)
1	Highly Suitable (S1)	1658.1	11.6
2	Moderately Suitable (S2)	673.7	4.7
3	Marginally Suitable (S3)	4895.3	34.3
4	Not Suitable (N)	6728.4	47.2
5	Habitation	62.1	0.4
6	Waterbody	220.0	1.5
Total		14237.8	100.0

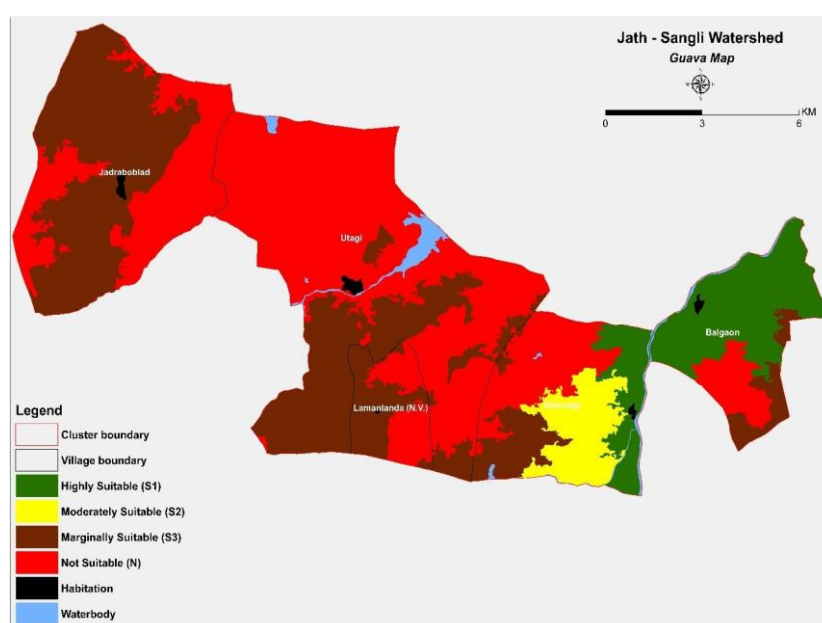


Fig. 4.36 Soil site suitability map for Guava cultivation

4.8.15 Soil-Site Suitability for Pomegranate Cultivation

The soils of the watershed were evaluated for pomegranate cultivation based on crop-specific requirements. The distribution of suitability classes is presented in Table 4.41 and Fig. 4.37. The results indicate that 1658.1 ha (11.6% of the total geographical area of the watershed) is classified as highly suitable (S1), providing favorable conditions for pomegranate growth and productivity. Only 673.7 ha (4.7%) area covered under moderately suitable (S2). A considerable portion of the watershed (one-third of the area)

is categorized as marginally suitable (S3), reflecting moderate to severe constraints related to soil properties and terrain, which may restrict yield.

Around 50% area of the watershed area is not suitable (N) for pomegranate cultivation due to severe limitations associated with soil, topography, and water stress, nutrient deficiency and high stony soil. Overall, the evaluation suggests that while nearly three-twentieth of the watershed is highly suitable for pomegranate cultivation.

Table 4.41 Area under suitability sub-classes for Pomegranate cultivation

Sr.No.	Suitability classes	Area (ha)	Percent (%)
1	Highly Suitable (S1)	1658.1	11.6
2	Moderately Suitable (S2)	673.7	4.7
3	Marginally Suitable (S3)	4381.3	30.7
4	Not Suitable (N)	7242.4	50.8
5	Habitation	62.1	0.4
6	Waterbody	220.0	1.5
Total		14237.8	100.0

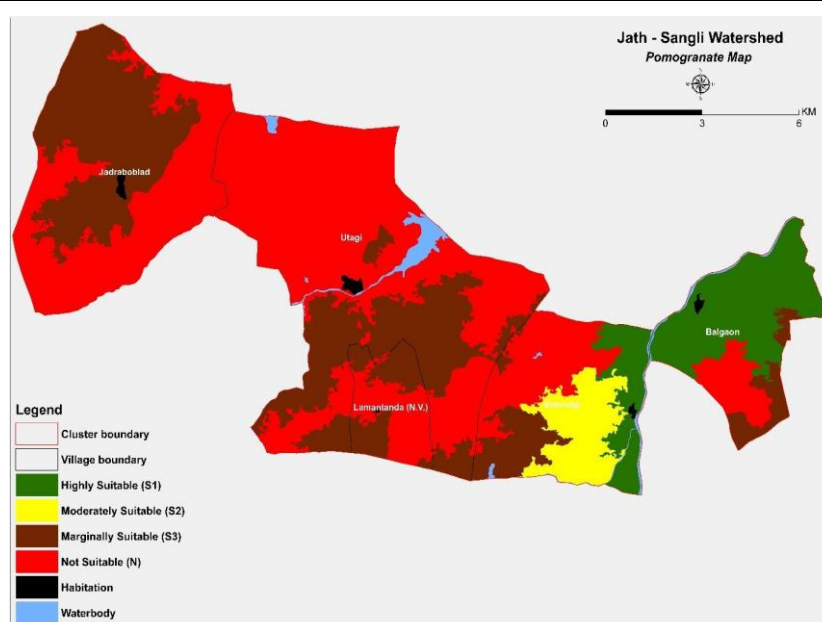


Fig. 4.37 Soil site suitability map for Pomegranate cultivation

4.8.16 Soil-Site Suitability for Onion Cultivation

The crop suitability assessment for onion shows that the majority of the study area, 7952 ha (55.8%), is moderately suitable (S2) for cultivation as presented in Table 4.42 and Figure 4.38. The major limitation in these areas is low rainfall. Efficient irrigation practices such as drip irrigation or micro sprinkler irrigation systems can be adopted to support crop growth and yield. Highly suitable (S1) land covers 19.9% (2839.1 ha) of the area. These areas offer favorable conditions for onion cultivation. Marginally suitable (S3) land covers 21.1% (3012.3 ha) of the area. Only a small proportion of area 1.0% (151.4 ha) is not suitable (N) for onion cultivation. This indicates that the region has a strong potential for onion cultivation.

Table 4.42 Area under suitability sub-classes for Onion cultivation

Sr.No.	Suitability classes	Area (ha)	Percent (%)
1	Highly Suitable (S1)	2839.1	19.9
2	Moderately Suitable (S2)	7952.6	55.8
3	Marginally Suitable (S3)	3012.3	21.1
4	Not Suitable (N)	151.4	1.0
5	Habitation	62.1	0.4
6	Waterbody	220.0	1.5
Total		14237.8	100.0

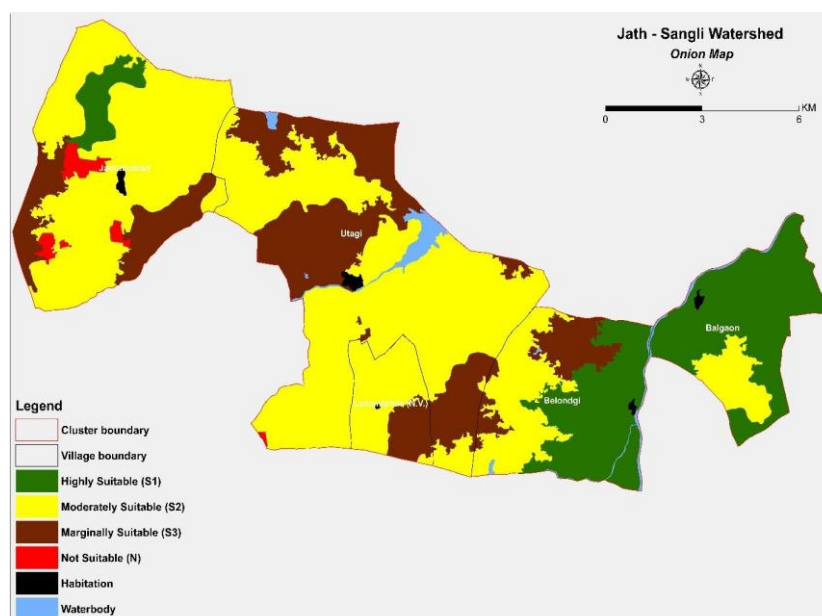


Fig. 4.38 Soil site suitability map for Onion cultivation

4.8.17 Soil-Site Suitability for Tomato Cultivation

The crop suitability assessment for tomato shows that, 2876 ha (20.2%), is not suitable (N) for cultivation, as presented in Table 4.43 and figure 4.39. The primary limiting factor in these areas is shallow soil. Highly suitable (S1) land covers 1658.16 ha (11.6%) area, offering the most favorable conditions for tomato production. Moderately suitable (S2) land accounts for 1654 ha (11.6%), and about 7767 ha (54.5%) of land is marginally suitable (S3) for tomato cultivation due to significant limitations in rainfall and terrain.

Table 4.43 Area under suitability sub-classes for Tomato cultivation

Sr.No.	Suitability classes	Area (ha)	Percent (%)
1	Highly Suitable (S1)	1658	11.6
2	Moderately Suitable (S2)	1654	11.6
3	Marginally Suitable (S3)	7768	54.5
4	Not Suitable (N)	2876	20.2
5	Habitation	62.15	0.4
6	Waterbody	220.0	1.5
Total		14237.8	100.0

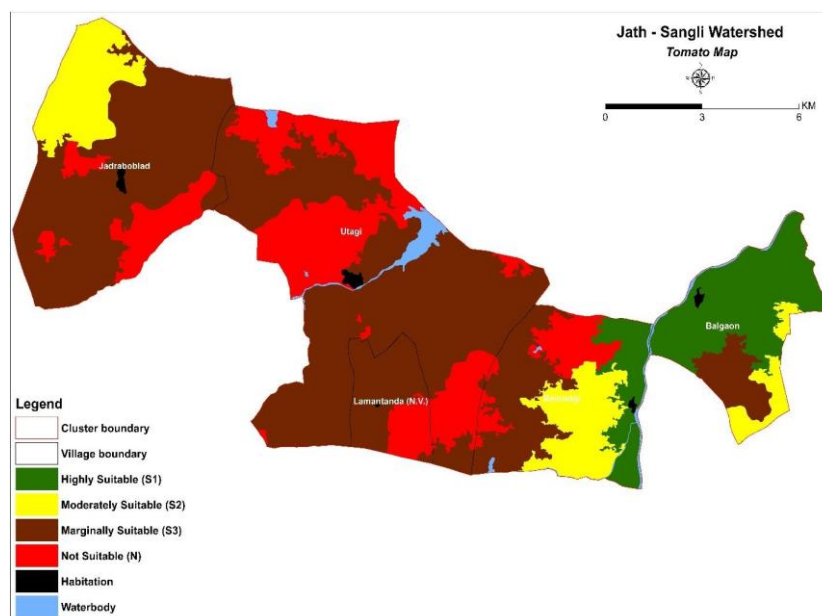


Fig. 4.39 Soil site suitability map for Tomato cultivation

4.9 Morphometric Analysis Jath Cluster, Sangli

In this study, runoff estimation, groundwater potential zone (GWPZ) mapping, and soil and water conservation (SWC) planning were performed at the village-cluster level to facilitate site-specific evaluation 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 Jath cluster in Sangli district, Maharashtra, comprises five villages, which form the study cluster containing three sub-watersheds (Fig. 4.40). Sub-watershed-wise area, stream order, elevation range, and drainage network characteristics are given in Table 4.44 and Fig. 4.41.

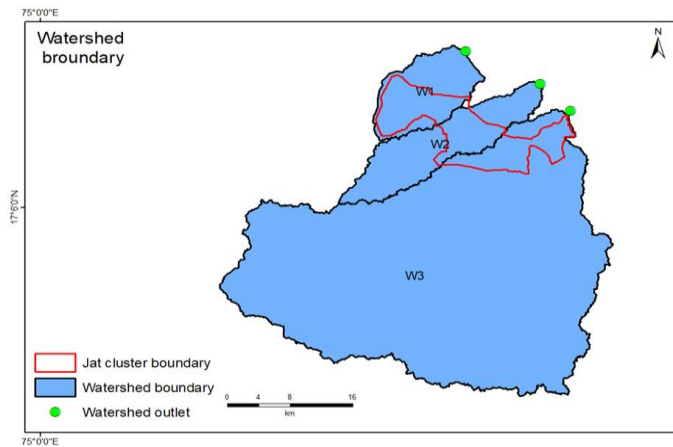


Fig. 4.40: Map of Jath cluster, Sangli depicted through sub-watershed

Table 4.44: Distribution of area under different sub-watershed, Jath, Sangli

Sr. No.	Sub-watershed name	Order	Elevation (m)	Area (km ²)	Flow origination
1	W1	4 th	402-589	114.0	North-east
2	W2	4 th	395-678	149.9	North-east
3	W3	5 th	397-762	1216.4	North-east
Total				1480.4	

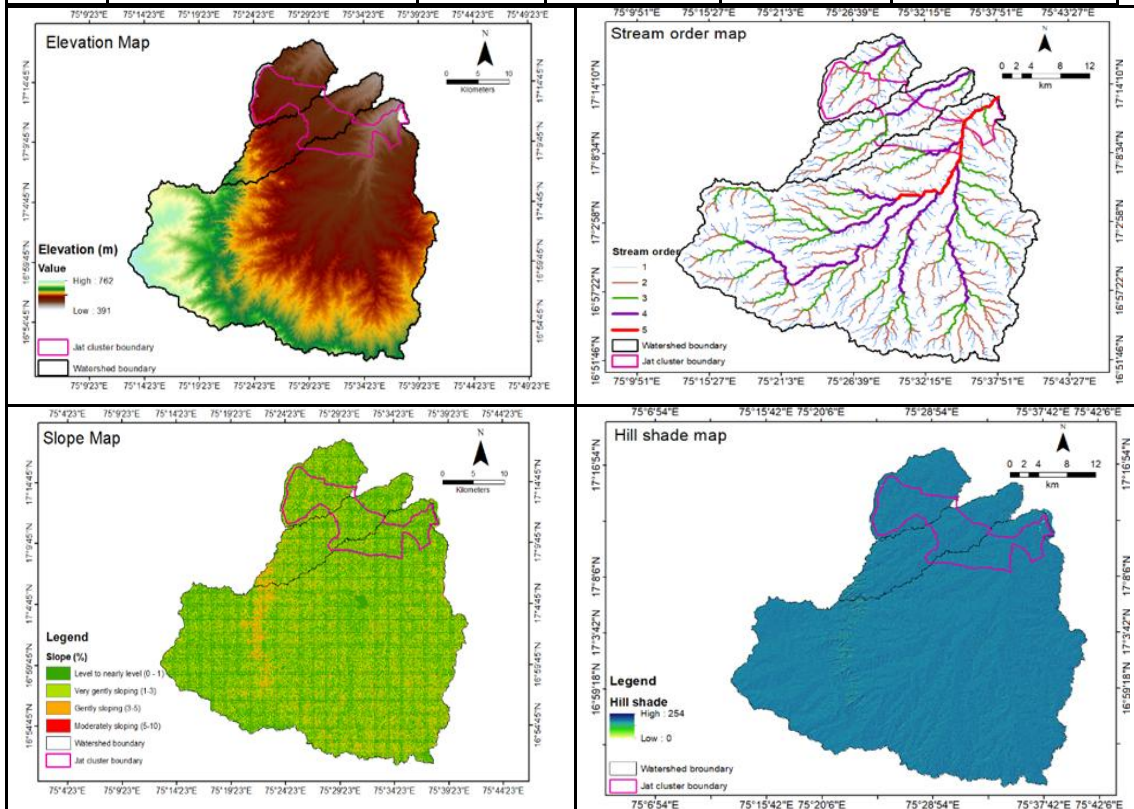


Fig. 4.41: Elevation, stream network, slope and hill shade map of sub-watershed

Linear aspect

Linear morphometric parameters describe the stream network characteristics and their influence on runoff and watershed behavior. The analysis of the three sub-watersheds shows clear variation in drainage characteristics. Sub-watershed W3 has the highest number of streams (913) and the greatest total stream length (1324.4 km), indicating a well-developed drainage network, whereas W1 has the lowest values (Table 4.45). The bifurcation ratio ranges from 4.0 in W1 to 5.3 in W3, suggesting comparatively greater structural influence in W3. The mean channel length and valley length are also highest in W3, reflecting more mature channel development, while W1 records the lowest values. The channel index is highest in W3 (1.3), indicating greater channel sinuosity. The basin perimeter is also largest in W3 (204 km), confirming it as the most extensive sub-watershed, whereas W1 is the smallest.

Table 4.45: Linear morphometric parameters of sub-watersheds, Jath cluster, Sangli

Sr.no.	Morphometric parameter	Symbol	Unit	W1	W2	W3
1	No. of streams	Nu	No	81	116	913
2	Stream length	Lu	km	117.7	160.7	1324.4
3	Bi-furcation ratio	Rb	-	4.0	5.28	5.3
4	Mean channel length	Cl	km	18.54	37.22	66.34
5	Valley Length	VI	km	17.2	36.03	64.21
6	Channel Index	Ci	-	1.2	1.3	1.05
7	Minimum areal distance	Adm	km	16.2	35.2	63.14
8	Valley Index	Vi	-	1.06	1.8	1.06
9	Basin perimeter	P	km	51.2	84.9	204.0

Areal Aspects

Areal parameters describe the two-dimensional characteristics of the watershed, including basin shape, size, and drainage efficiency, which influence runoff generation and groundwater recharge. The analysis shows variation in basin geometry among the three sub-watersheds. The basin area is highest in W3 (1216.4 km²) and lowest in W1 (114 km²). Similarly, the mean basin width is greater in W3 (18.1 km). The form factor (Ff) and elongation ratio (Re) are highest in W3 (0.3 and 0.4), indicating a comparatively more circular basin shape, whereas W1 and W2 show lower values, suggesting elongated basin characteristics. The circularity ratio (Rc) is also maximum in W3 (0.4). The compactness coefficient (Cc) is highest in W2 (2.0), indicating greater basin irregularity.

The standard sinuosity index (Ssi) ranges from 1.0 in W2 to 1.2 in W3, indicating relatively higher channel sinuosity in W3 (Table 4.46). Drainage parameters further highlight variations in watershed characteristics. Stream frequency (Fs) is highest in W2 and W3 (0.8 km⁻²) and lowest in W1 (0.7 km⁻²). The drainage density (Dd) is nearly similar in W1 and W2 (1.1 km/km²) but higher in W3 (1.3 km/km²). Drainage intensity

(Di) follows a similar trend, with the highest value observed in W3 (1.8). The length of overland flow (Lg) is greatest in W3 (0.5 km) and lowest in W1 (0.17 km).

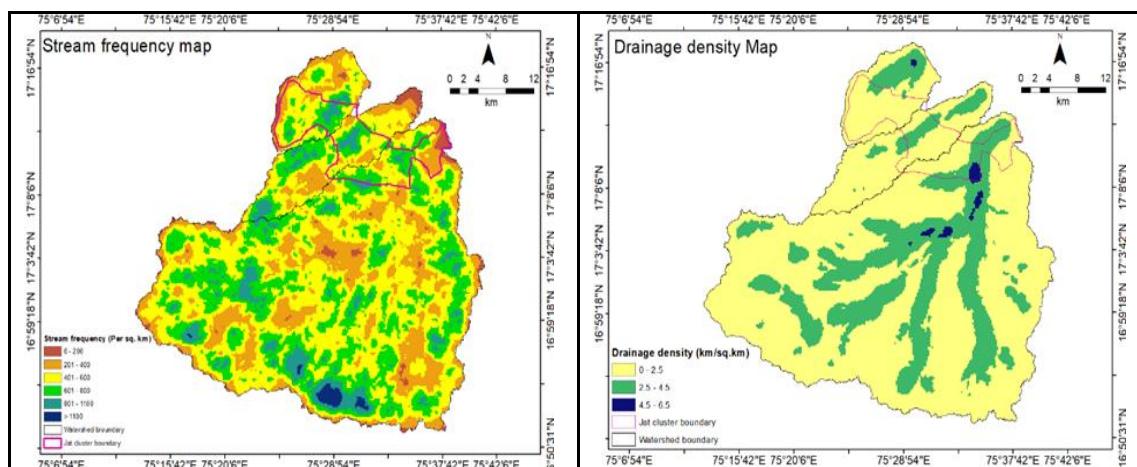


Fig. 4.42: Steam frequency and drainage density map of sub-watershed

Table 4.46: Areal morphometric parameters of sub-watersheds, Jath cluster, Sangli

Sr. No.	Parameter	Symbol	Method/Formula	Unit	W1	W2	W3
1.	Mean basin width	Wb	$Wb = A/Lb$	km	5.9	3.9	18.1
2.	Basin area	A	GIS Analysis	km ²	114.0	150.0	1216.4
3.	Relative perimeter	Pr	$Pr = A/P$	km	2.2	1.8	6.0
4.	Length area relation	Lar	$Lar = 1.4 * A^{0.6}$		24.0	28.3	99.4
5.	Lemniscate's	k	$K = Lb^2/A$		3.2	9.6	3.7
6.	Form factor	Ff	$Ff = A/Lb^2$		0.3	0.1	0.3
7.	Elongation ratio	Re	$Re = 2/Lb * (A/\pi)^{0.5}$		0.2	0.23	0.4
8.	Circularity ratio	Rc	$Rc = 12.57 * (A/P^2)$		0.5	0.3	0.4
9.	Compactness coefficient	Cc	$Cc = 0.2841 * P/A^{0.5}$		1.4	2.0	1.7
10.	Standard sinuosity index	Ssi	$Ssi = Ci/Vi$		1.1	1.0	1.2
11.	Stream frequency	Fs	$Fs = Nu/A$		0.7	0.8	0.8
12.	Drainage Density	Dd	$Dd = Lu/A$	km/km ²	1.0	1.1	1.3
13.	Drainage Intensity	Di	$Di = Fs/Dd$		0.7	0.8	1.8
14.	Length of Overland Flow	Lg	$Lg = A/2 * Lu$		0.17	0.47	0.5

Relief Aspects

Relief parameters describe the vertical characteristics of the watershed, reflecting terrain steepness and potential erosion intensity. The maximum basin elevation (Z) is highest in W3 (762 m) and lowest in W1 (589 m). Similarly, the total basin relief (H) is maximum in W3 (398 m) and minimum in W1 (304 m) (Table 4.47). The relief ratio (Rhl) is highest in W1 (15.8), indicating steeper terrain conditions, whereas W3 shows the lowest value (5.9). The relative relief ratio (Rhp) is greatest in W1 (592.7), followed by W2 and W3, suggesting higher relief intensity in W1. The ruggedness number (Rn) is maximum in W3 (0.43), indicating more dissected and erosion-prone terrain, while W1 records the lowest value (0.31). Similarly, the Melton ruggedness number (MRn) is highest in W1 (40.8), suggesting comparatively greater susceptibility to runoff and erosion processes.

Slope analysis shows that the terrain across the three sub-watersheds (W1, W2, and W3) is predominantly very gently sloping (1–3%) and gently sloping (3–5%). Approximately 32%, 27%, and 27.7% of the total area in W1, W2, and W3, respectively, fall under the gently sloping category. In contrast, moderately sloping land (5–10%) accounts for 29.4%, 17.0%, and 17.7% in W1, W2, and W3, respectively, indicating relatively undulating terrain conditions.

Table 4.47: Relief morphometric parameters of sub-watersheds, Jath cluster, Sangli

Sl. no.	Parameters	Symbol	Methods/Formula	W1	W2	W3
1.	Height of at basin mouth	z	GIS Analysis/DEM	402	395	397
2.	Maximum height of the basin	Z	GIS Analysis/DEM	589	678	762
3.	Total basin relief	H	$H = Z - z$	304	357	398
4.	Relief ratio	Rhl	$Rhl = H / Lb$	15.8	9.4	5.9
5.	Relative relief ratio	Rhp	$Rhp = H / P * 100$	592.7	420	195.0
6.	Ruggedness number	Rn	$Rn = Dd*(H/1000)$	0.31	0.38	0.43
7.	Melton ruggedness number	MRn	$MRn = H / A^{0.5}$	40.8	29.1	11.4

Implications for Soil and Water Conservation

Based on the morphometric analysis, sub-watershed W3 requires priority attention for soil and water conservation planning due to its highest drainage density (1.3 km/km²), stream frequency (0.8 km⁻²), ruggedness number (0.43), and total basin relief (398 m), which collectively indicate higher runoff generation and erosion susceptibility.

Structural measures such as check dams, gabion structures, and contour bunding should be implemented along higher-order streams to reduce flow velocity and sediment transport. Vegetative measures including afforestation, grassed waterways, and agroforestry practices are recommended, particularly on moderately sloping lands (5–10%), to enhance infiltration and reduce surface runoff.

In contrast, W1, characterized by a higher relief ratio (15.8) and Melton ruggedness number (40.8), requires slope stabilization measures such as terracing and contour farming to minimize rapid runoff and soil loss. Since W3 exhibits relatively circular basin characteristics (higher form factor and elongation ratio), it may experience quicker peak flows during rainfall events. Therefore, runoff harvesting structures such as farm ponds and percolation tanks should be developed to enhance groundwater recharge.

For W2, where the compactness coefficient is highest (2.0) and stream frequency is relatively high, an integrated watershed management approach combining drainage line treatment and appropriate land-use planning is recommended. Overall, adopting sub-watershed-specific soil and water conservation measures based on morphometric characteristics will improve hydrological stability, reduce erosion risk, and promote sustainable watershed development.

4.9 Soil and Water Conservation measures

A soil and water conservation plan has been prepared for the village cluster watershed in Jath Taluka, Sangli District, a region widely recognized as drought-prone where soil erosion, erratic rainfall, and limited groundwater recharge have affected agricultural productivity. To address these challenges, a comprehensive plan has been developed based on land capability assessment and geospatial analysis carried out during the watershed planning process and based on the LRI. The proposed interventions have been aligned with existing land use, soil depth classes, slope categories, drainage characteristics, and runoff behaviour identified within the watershed. These parameters were analyzed using spatial datasets and morphometric evaluation of the drainage network to understand watershed response to rainfall and runoff generation. Each conservation measure has been spatially allocated to ensure technical suitability and site-specific implementation.

The watershed area is predominantly under agricultural land use, with soil depth varying from very shallow to deep and slopes that permit the implementation of mechanical soil and water conservation measures. Field bunding and strengthening of existing bunds, along with provisions for the safe disposal of excess runoff, constitute a major component of the proposed treatments. Farm ponds are proposed in conjunction with banded agricultural fields at suitable locations, while lined farm ponds have been identified in areas where soil conditions indicate higher seepage potential. These measures are intended to regulate surface runoff, enhance soil moisture retention, and support supplemental irrigation within cultivated lands.

Conservation bench terraces are proposed in agricultural areas where bunds are absent and where slope and soil depth conditions permit terracing. The Broad Bed and

Furrow (BBF) system is recommended across several agricultural patches, both as an independent intervention and in combination with field bunds and farm ponds, including lined structures where necessary. These measures are designed to promote in situ moisture conservation, improved drainage, and efficient utilization of rainfall under rainfed agricultural conditions.

Vegetative measures are proposed as complementary treatments to structural interventions. Afforestation combined with in situ moisture conservation practices is recommended in areas identified with scrub or sparse tree cover. Horticultural plantations are proposed along with appropriate moisture conservation measures, and in selected locations these plantations are supported by farm ponds, including lined structures where required. Stream bank plantation is proposed along identified drainage lines to stabilize stream banks, reduce bank erosion, and improve riparian vegetation cover.

Water harvesting and renovation measures are also incorporated throughout the watershed. Rooftop rainwater harvesting systems are proposed for built-up areas to capture and utilize rainfall runoff. Renovation and desilting of existing farm ponds are proposed to restore their storage capacity, while identified natural and artificial water bodies within the watershed are recommended for rehabilitation. Structural interventions such as Cement Nala Bunds (CNB) and Earthen Nala Bunds (ENB), along with repair and desilting of existing drainage channels, are proposed to regulate runoff and enhance groundwater recharge in suitable recharge zones identified through groundwater potential analysis. Road-related drainage and protection works are recommended to safely convey runoff and prevent erosion along transportation corridors. Additionally, localized in situ moisture conservation measures are proposed to ensure effective treatment of small and fragmented land parcels.

The proposed interventions collectively constitute an integrated watershed treatment framework, combining mechanical, vegetative, and water harvesting measures to reduce soil erosion, regulate runoff, enhance groundwater recharge, and improve soil moisture availability for sustainable agricultural production. The types and extent of the proposed measures for the village cluster watershed in Jath Taluka are summarized in Table 4.48 and depicted in Fig. 4.43.

Table 4.48 Proposed soil and water conservation (SWC) plan for Jath watershed.

Sr. No.	Proposed SWC Plan
1	Field bund/Strengthening of existing bund with safe disposal of runoff water, Farm pond
2	Conservation Bench Terrace in Unbunded Field/Field bund/Strengthening of existing bund with safe disposal of runoff water
3	Broad Bed and Furrow (BBF) system/Field bund/Strengthening of existing bund with safe disposal of runoff water
4	Field bund/Strengthening of existing bund with safe disposal of runoff water
5	Broad Bed and Furrow (BBF) system/Field bund/Strengthening of existing bund with safe disposal of runoff water, Farm pond

6	Field bund/Strengthening of existing bund with safe disposal of runoff water, Farm pond with Lining
7	Afforestation, In-situ Moisture Conservation Measures
8	Renovation of Waterbody as per the site condition
9	Afforestation, In-situ Moisture Conservation Measures, Farm pond
10	Broad Bed and Furrow (BBF) system/Field bund/Strengthening of existing bund with safe disposal of runoff water, Farm pond with Lining
11	Road
12	Rooftop Rainwater Harvesting
13	Stream Bank Plantation
14	Renovation/Desilting of Farm pond as per the site condition
15	Horticultural Plantation, In-situ Moisture Conservation Measures
16	Canal
17	In-situ Moisture Conservation Measures, Farm pond
18	In-situ Moisture Conservation Measures

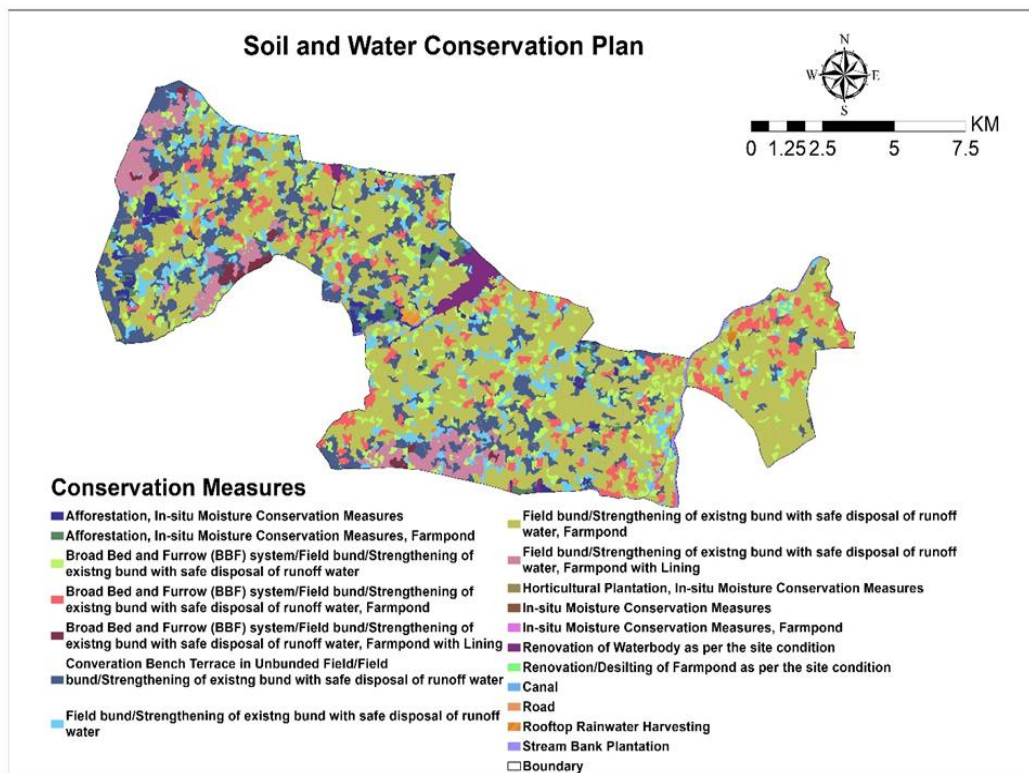


Fig. 4.43: Soil and Water Conservation measures proposed for Jath watershed

CHAPTER 5

SUMMARY AND CONCLUSION

5.1 SUMMARY

- The watershed is located in a semi-arid and drought-prone region of Sangli district, characterized by low and highly variable rainfall, making irrigation and water resource management critical for sustaining agricultural productivity.
- The local economy is predominantly agriculture-based, with the majority of farmers belonging to the small and marginal landholding category, having an average operational holding of approximately 2.4 ha.
- The cropping pattern has gradually shifted toward commercial and horticultural crops such as grapes and pomegranate, while tur (pigeon pea) remains an important crop under irrigated conditions.
- The overall cropping intensity is about 126.5%, which is constrained by limited availability of irrigation water during the summer season. Borewells serve as the primary irrigation source during Kharif and Rabi seasons, whereas farm ponds provide supplementary irrigation during the summer months.
- The watershed lies within the Deccan Trap basalt geological formation, and the dominant geomorphic units include Undulating Midland (48.0%) and Undulating Lowland (17.7%). Agriculture is the predominant land use, covering approximately 95.5% of the total watershed area.
- The terrain is predominantly very gently sloping (1–3%) to gently sloping (3–5%), with clay as the dominant soil texture (81.71%). Soil depth varies across the watershed, with moderately deep (25–50 cm) and shallow (<25 cm) soils occupying a major portion of the area.
- Soil erosion assessment indicates that moderate erosion dominates (87.55%), while 8.68% of the watershed falls under severe erosion, indicating the need for targeted soil and water conservation interventions.
- Morphometric analysis of the watershed revealed variations in drainage characteristics, basin geometry, and relief parameters, which influence runoff generation, erosion susceptibility, and groundwater recharge potential across the sub-watersheds.
- The study involved spatial mapping of soil properties, hydrological parameters including rainfall–runoff relationships, and delineation of groundwater potential zones using geospatial techniques.
- Soil–site suitability evaluation for major crops was carried out to support watershed-based alternate land use planning and sustainable crop selection.

- Based on land capability, slope, soil depth, and hydrological conditions, a site-specific soil and water conservation (SWC) plan was developed incorporating mechanical, vegetative, and water harvesting measures to improve soil moisture conservation and groundwater recharge within the watershed.

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 Jath watershed, Sangli district.

The assessment confirms that the agricultural system is highly vulnerable to rainfall variability, with crop production critically dependent on supplemental irrigation, which is limited during the summer. The transition to high-value crops like grapes and pomegranates signifies a commercial potential but intensifies the pressure on water resources. The soil assessment highlights spatial variations in soil depth (shallow to moderate) and the prevalence of clay-textured soils, which, when combined with the undulating terrain, results in widespread moderate soil erosion. The identification of areas under severe erosion provides a clear mandate for location-specific interventions.

To conclude, the present Land Resource Inventory (LRI) study of the Jath cluster watershed in Sangli district provides a comprehensive assessment of terrain characteristics, soil resources, land use patterns, hydrological conditions, and groundwater potential using integrated geospatial analysis and field-based observations. The study area, characterized by semi-arid climatic conditions, shallow to moderately deep clayey soils, gently undulating terrain, and moderate soil erosion, highlights the need for sustainable land and water management practices. The evaluation of soil-site suitability for major crops, together with the delineation of groundwater potential zones and runoff characteristics, provides a scientific basis for location-specific soil and water conservation measures and alternate land use planning. Implementation of the proposed interventions, including mechanical and vegetative conservation practices and water harvesting structures, will help reduce runoff losses, control soil erosion, enhance groundwater recharge, and improve soil moisture availability. Overall, the findings of this study provide a valuable framework for watershed-based resource management and can support sustainable agricultural development and improved livelihoods for farming communities in the Jath watershed.



