American Journal of Rural Development, 2025, Vol. 13, No. 1, 7-22
Available online at http://pubs.sciepub.com/ajrd/13/1/2
Published by Science and Education Publishing
DOI:10.12691/ajrd-13-1-2

Sustainable Development Planning of the Tribal Villages in the Kalsubai-Harishchandragad Wildlife Sanctuary (MS), India

Mr. Sandip N. Deshmukh[1,2,*], Dr. Ravindra G. Jaybhaye[3]

[1]Research Scholar, Department of Geography, Savitribai Phule Pune University, Pune, India
[2]Assistant Professor, Department of Geography, Sangamner Nagarpalika Arts, D. J. Malpani Commerce and B.N.Sarda Science College (Autonomous), Sangamner-422605 (MS), India
[3]Sr. Professor, Department of Geography, Savitribai Phule Pune University, Pune, India
*Corresponding author: geodeshmukh1@gmail.com

Received February 05, 2025; Revised March 06, 2025; Accepted March 13, 2025

Abstract India is predominantly a rural nation. Day by day, the increasing population is destroying natural resources due to excessive consumption. Therefore, it is critical to effectively plan, use, and conserve natural resources for future generations through sustainable development planning. The main objective of this study is to prepare action plans for proper utilization and conservation of natural resources by considering local geographical factors in the tribal villages of Kothale and Kumshet. The study includes significant use of the field visit, questionnaire, group discussions, toposheet, satellite data, and geospatial tools. The sustainable development of these tribal villages will result in increased economic, social, and ecological prosperity through effective planning and utilization of their natural resources. Based on geospatial techniques and field work, we have examined various aspects such as topography, slope analysis, soil erosion, soil depth, groundwater level, soil texture, soil land capability, land use, and land cover. We can use these elements to formulate more effective action plans for the village's development, considering its local needs, problems, and available natural resources. This study is crucial for effective planning, conservation of natural resources, economic development of tribal communities, and safe livelihood, encompassing aspects such as water conservation, soil conservation, watershed management, forest conservation, cropping patterns, land use, land cover, human wildlife conflict, landslides, and tourism. Studying local geographical factors can enhance the depth and proactiveness of necessary policies and programs for local development planning, thereby facilitating their more effective implementation. These plans will help to promote conservation and sustainable development of natural resources, solve local problems, and enable more effective implementation of policies and programs required for development planning. We can effectively implement initiatives such as watershed development, the *Jalyukta Shiwar Schem*e, the *KT weir* (*Kolhapur Type Bandhara*), afforestation, wasteland development, and crop cultivation. Furthermore, it will assist in achieving some of the United Nations' 17 sustainable development goals.

Keywords: *tribal, natural resources, sustainable development, conservation, policies, programs*

Cite This Article: Mr. Sandip N. Deshmukh, and Dr. Ravindra G. Jaybhaye, "Sustainable Development Planning of the Tribal Villages in the Kalsubai-Harishchandragad Wildlife Sanctuary (MS), India." *American Journal of Rural Development*, vol. 13, no. 1 (2025): 7-22. doi: 10.12691/ajrd-13-1-2.

1. Introduction

Gradually, the population burden on the Earth's surface grew. Natural resources meet the fundamental needs of humans, flora, and fauna. Therefore, the overconsumption of resources to meet these needs leads to the depletion of natural resources. Conserving resources is critical to ensuring their availability for future generations while still meeting our current needs [1].

A village development plan is essentially a framework for developing rural or tribal areas that are lagging behind in socio-economic development, as well as for the protection and sustainable use of natural resources [2]. When developing the action plans for land, water, forest, and hazard development, they carefully considered both conservation and development aspects in a careful manner [3] Sustainable developmental planning is beneficial for effective management and improved use of natural resources to enhance people's living conditions and fulfill a population's growing needs [3].

The Western Ghats' Kalsubai Harishchandragad Wildlife Sanctuary (KHWS), known for its rich biodiversity, contains the study area. Therefore, tribal villages have abundant natural resources, but the local community also faces some challenges. This study examined the local issues, explored the available natural resources, proposed solutions to the problems, and proposed strategies for sustainable development that promote economic growth, efficient use, and preservation of the natural resources with the help of geospatial techniques.

The Brundtland Commission first defined sustainable development (SD) as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" in 1987 [4]. The Brundtland Commission described sustainable development as a paradigm based on both environmental and developmental aspects. The Triple Bottom Line (TBL) model, which integrates environmental, economic, and social aspects, is commonly known as sustainable development [5,6].

The expanding population requires food, clothes, dwellings, fuel, and fodder for their livestock. Besides suffering lower incomes, rural individuals also face challenges such as limited access to clean drinking water, inadequate healthcare, and illiteracy, all of which have a negative impact on their quality of life [7]. Land is India's essential resource, providing a livelihood to the rural population. Water is a significant resource for improving agricultural productivity. By using appropriate technology, it is feasible to effectively utilize these natural resources in a manner that is beneficial to the environment and can be preserved in the future [8].

Geospatial technologies are modern tools that allow the development of a spatial data infrastructure for any given geographic region. This system plays an essential role in the process of planning, monitoring, and decision-making across every level of government [9]. GIS and geographical data systems may help in the planning, monitoring, and information exchange among different organizations involved in rural and tribal development administration [10]. A local government must gather comprehensive baseline data using a planning tool in order to select priority regions and specific individuals, distribute funds, monitor activities, evaluate outcomes, analyze limitations, and mobilize resources, among other responsibilities [11]. Geospatial technology at a micro level is essential for disseminating information at grassroots levels to promote and monitor sustainable development in rural areas. The use of geospatial technology is enhancing the planning, designing, and implementation of projects, with a specific focus on meeting the needs of underprivileged groups and individuals at the village leve [12]. Geospatial technology is essential to creating timely and precise data that is used for planning and decision-making at all levels, from macro to micro, for a particular area [13,14]. The preparation of the action plan for the study area used geospatial techniques, which are also important tools for analysis, planning, and management.

The Scheduled Tribe population, which inhabits the study area, faces numerous challenges. Tribal communities are characterized by their remote location, insufficient income, and lack of social consciousness, lack of political clout, rich cultural heritage, uncomplicated and reliable behaviour, and peaceful, natural lifestyles. They are considered the economically weakest members of society and live at the basic subsistence level [15]. The main objectives of this study are to prepare action plans for the sustainable development of natural resources, which can significantly enhance tribal people's quality of life while also contributing to resource conservation.

A village development plan is essentially a strategy for advancing underdeveloped, tribal, or rural communities' social and economic development. Any initiative aiming at advancing the growth of a region or any segment of its inhabitants requires the development of human resources, the area's production potential, and the construction of fundamental social and physical infrastructure for long-term success. Tagore and Gandhiji, the influential thinkers of model villages, always emphasized self-reliance and village resource integration (2). Thill (2011) conducted a study on the model village and its sustainable natural resource management, village self-governance, modern policies, participatory development, migration, social equity, abundance, and true democracy in Ralegan Siddhi (Anna Hazare, the main leader behind the village), located in the dry lands of Maharashtra [16].

2. Study Area

Kumshet and Kothale tribal villages are located in the KHWS in the Western Ghat region, within the Ahmednagar(Ahilyanagar) district's Akole Tehsil. The Kumshet and Kothale villages cover an area of 29.85 sq km and 7.97 sq km, respectively. Hilly terrain surrounded the villages on three sides. The Kumshet village is located between the latitudes of $19^{0}\ 25^{'}\ 58^{''}$ N to $19^{0}\ 28^{'}\ 59^{''}$ N and the longitudes of $73^{0}\ 41^{'}\ 03^{''}$ E to $73^{0}\ 44^{'}\ 45^{''}$ E. Additionally, Kothale is located between $19^{0}\ 22^{'}\ 40^{''}$ N to $19^{0}\ 24^{'}\ 59^{''}$ N and the longitudes of $73^{0}\ 48^{'}\ 18^{''}$ E to $73^{0}\ 50^{'}\ 33^{''}$ E. These villages are located in the Mula river drainage basin area. Kumshet village has a relative relief of 600 meters due to a maximum height of 1405 meters toward the west at *Ajobha* Fort, the origin point of the Mula River, and a minimum height of 805 meters located in the east at the main Mula River basin.

The village's slope ranges from northwest to southeast. The Kothale village at *Bhairvgad* toward the west has a maximum height of 1218 meters and a minimum height of 777 meters; therefore, relative relief is 441 meters. The village's slope ranges from southwest to northeast.

The KHWS, a protected area, is the natural habitat for a large variety of flora and fauna, like leopards, wild bars, deer, etc. The major problems in the study area include water scarcity for drinking and irrigation in summer season, soil erosion, migration, human-wildlife conflict, landslide areas, and unemployment. A few aspects of villages, forest regions, hilly terrain, trekking destinations, high rainfall, and traditional knowledge are essential to maintaining the environment and promoting sustainable development that will benefit the tribal people's economic development.

3. Data Collection

The primary data was collected with the help of a prepared questionnaire as well as fieldwork and the collected GPS location at the field visit time. Secondary data was also collected in different ways, such as Census of India, SOI Toposheet (Survey of India), and satellite data as like Short for Shuttle Radar Topographic Mission (SRTM), Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER), Cartosat Digital Elevation Model (CartoDEM), etc.

4. Methodology

The present investigation is based on fieldwork, a Geographical Information System (GIS), Remote Sensing (RS), and a Global Positioning System (GPS). Once the data collection is complete, analyze it using advanced measurement techniques. They prepared various thematic maps using GIS software, including cadastral maps, contour maps, slope maps, land use and land cover, groundwater potential, soil depth, soil erosion, and an action plan for sustainable development planning for the villages. Using spatial data from the GIS domain, we prepared a composite layer and implemented a set of decision rules to produce an action plan for the development of natural resources. They included maps of slopes, cadastral features, groundwater, soil depth, soil erosion, soil texture, and land usage and coverage.

5. Discussion and Analysis

5.1. Demographic Characteristics

Environmental changes influence the human population, and population dynamics in turn impact the environment. Consequently, knowledge of population dynamics and population heterogeneity is fundamental to improving our understanding of how population size, composition, and distribution influence global environmental change [17]. Therefore, it is important to comprehend the research area's demographic characteristics. The 2011 census revealed that there were 667 and 732 people living in the villages of Kumshet and Kothale. Although these population sizes are relatively small, they have shown a consistent increase between 1961 and 2011. As per the 1961 census, Kumshet and Kothale village populations were 292 and 402. The villages' remote locations result in the highest concentration of Schedule Tribal Population (ST) in Kumshet, 97.75%, and Kothale, 98.22%. The sex ratio of the two villages is 867 and 997 per 1000 males (2011 Census), respectively. The literacy rate in Kumshet village is 37.24%, and in Kothale, it is 67.08%.

5.2. Cadastral Map

The cadastral maps of Kumshet and Kothale villages show the cadastral, watershed area, drainage, village, road, drainage, and district boundaries. The cadastral village map arranges land parcels and survey numbers chronologically [18]. According to government records, a parcel of land is defined as a designated area of land with legally recognized ownership rights [18,19]. A cadastral village map, which depicts the individual parcel of all government, public, freehold, encroachment, location, extent, value, ownership of land, undesirable possessions, is a type of 2D (two-dimensional) map [19,20]. For developmental purposes, it is very important to relate current natural resource information to the land parcels that are prepared by the Land Records Department [18,19,20].

Cadastral maps give all the details about land properties within a certain area, which is essential for making decisions about rural-level planning as well as for dealing with properties, collecting revenue, and creating and upholding village information systems. There are 136 survey numbers recorded in Kumshet village and 69 in Kothale village. These survey numbers are located in the village's central area, with hills and forests occupying the outer part. The region is hilly, so there are many streams (Map No. 1 and 2).

5.3. Contour Maps

Contours have been an essential part of height depiction in topographic maps [21]. Contour maps have been extremely useful in fields such as geography, geology, land surveying, military defence, and others [22]. Terrain contours determine the path of rivers and streams as well as the density and shape of road patterns [22]. The contour lines provide the essential topographic information about the study region required for sustainable development planning. Additionally, this data relates to watershed management, slope analysis, soil erosion, tree planning, landslide areas, tourist destinations, and land surveys, all of which are useful for the analysis and decision-making of the action plan. Therefore, the implementation of various schemes for conservation and community development requires the use of contour line maps in village development planning. For the villages, we prepared a contour line map using SRTM data and a 5-meter contour interval (Map No. 3 and 4).

5.4. Slope Map

The slope of a surface or terrain feature is its inclination or gradient, commonly expressed as the ratio of the vertical rise to the horizontal run. Tectonic activity, local geology, climate, and human activity all influence the slope, which is a significant component of the landscape. Slope analysis is an essential part of land-use reform. It gives guidelines for groundwater levels, landslide sites, watershed development, soil conservation requirements, land capability classification, and land use planning. Numerous factors influence slope development, including climate, vegetation types, soil, rock formations, weathered waste mantles, and waste land transport. The development of a particular area's slope is greatly influenced by human activities that alter the terrain, such as grazing and deforestation, plow work on slopes, mining, quarrying, road and canal construction, dam and reservoir construction, etc. [23]. Landslides have caused numerous casualties and extensive economic harm in hilly and mountainous regions around the world. Efficient planning and management, including slope evaluation for landslide prediction, mitigation strategies, and alert systems, can reduce social and economic losses from landslides [24,25,26].

Slope analysis plays a crucial role in village development planning, providing valuable insights into various aspects of sustainable development. The most important topographic factor is slope, which greatly influences vegetation growth, distribution, hydrological processes, soil resources, etc. The slope study also helps to minimize the risks from natural hazards such as flooding and landslides. Slope analysis helps determine the slope's nature, making it useful for selecting sites for continuous contour trenches (CCT), tree plantations, embankments, and other water conservation strategies that conserve soil and water.

The study area's slope ranges from 1-3% to 35–50%. The 43% area lies between the 15–35% slope angles, as well as Kumshet 540 hectares and Kothale 248.14 hectares under the 35–50% slope (Table No 1). As a result, the village's site and situation are favourable and important for the implementation of water, soil, and vegetation conservation (Map No 5 and 6).

Table No 1. Slope area (Area in hectares)

Slope (%)	1-3	3 -5	5-10	10-15	15-35	35-50
Kumshet	77.85	822.44	210.59	23.28	1295.76	540
Kothale	-	8.42	109.23	55.62	346.88	248.14

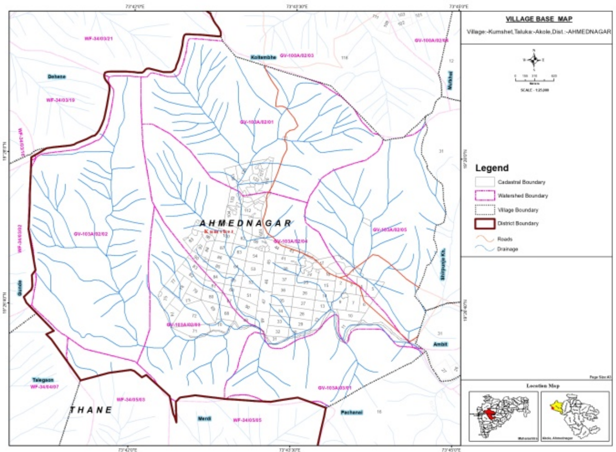


Figure No 1. Cadastral Map _ Kumshet

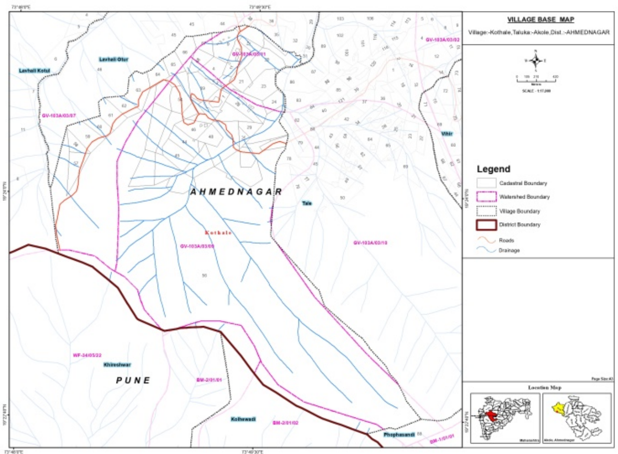


Figure No 2. Cadastral Map_ Kothale

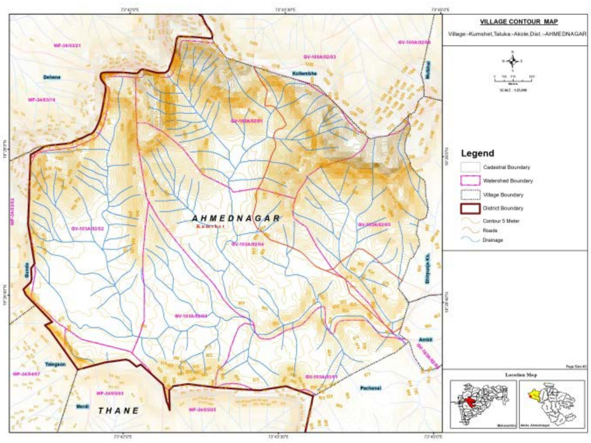


Figure No 3. Contour Map _ Kumshet

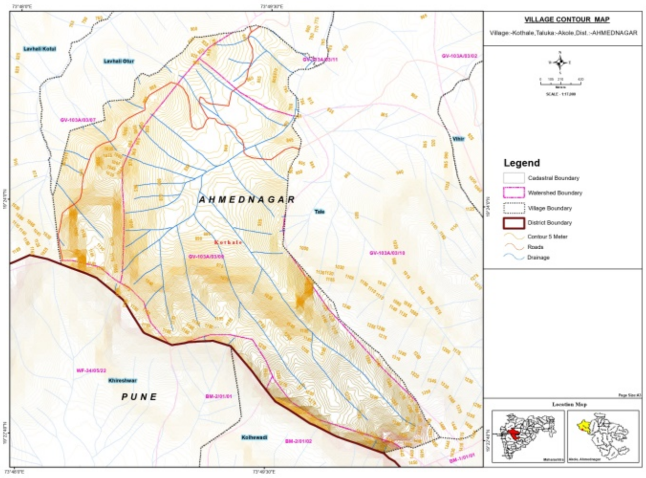
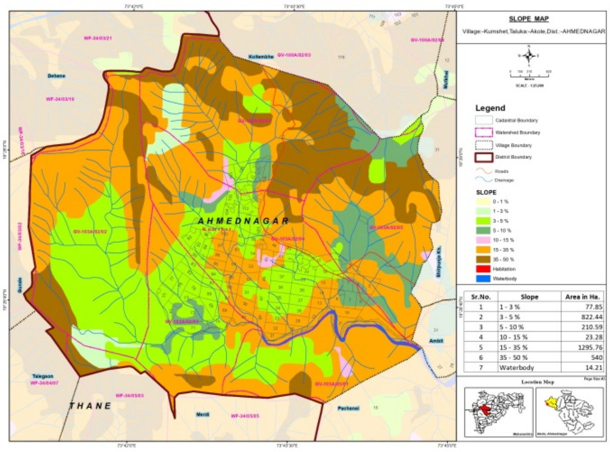
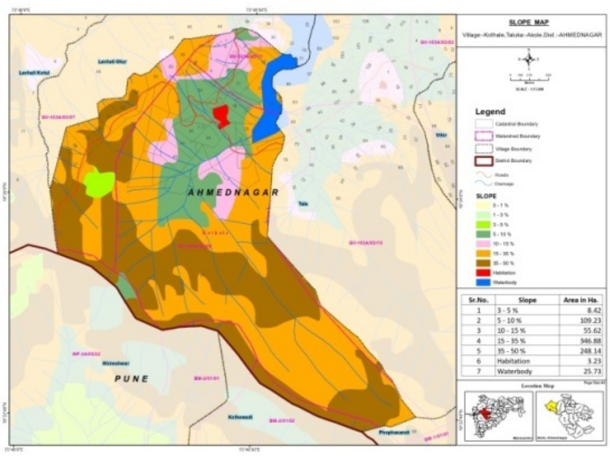


Figure No 4. Contour Map_ Kothale



Sr.No.	Slope	Area in Ha.
1	1 - 3 %	77.85
2	3 - 5 %	822.44
3	5 - 10 %	210.59
4	10 - 15 %	23.28
5	15 - 35 %	1295.76
6	35 - 50 %	540
7	Waterbody	14.21

Figure No 5. Slope Map _ Kumshet



Sr.No.	Slope	Area in Ha.
1	3 - 5 %	8.42
2	5 - 10 %	109.23
3	10 - 15 %	55.62
4	15 - 35 %	346.88
5	35 - 50 %	248.14
6	Habitation	3.23
7	Waterbody	25.73

Figure No 6. Slope Map_ Kothale

5.5. Land Use Land Cover (LULC)

Malthus (1798) predicted that population growth would eventually surpass Earth's production capacity and natural resource availability. Malthus initiated a discussion on the relationship between the dynamics of the human population and the availability of natural resources. A significant investigation of the relationship between human population and environment began in the second part of the twentieth century, when the likelihood of a Malthusian projection began to increase [27]. The scientific study and analysis of changes include a quantitative assessment of LULC at a specific location and period. LULC change impacts a region's sustainable development. Social equity, economic prosperity, and environmental sustainability, which form the foundation of sustainable development, fundamentally connect with LULC change [28]. While the rapid depletion of LULC in land use may temporarily benefit certain communities, it may condemn our future generations to life without the ecosystem services provided by LULC, further depriving them economically and aesthetically.

Nowadays, approaches to managing natural resources and keeping track of environmental changes are increasingly focused on changes in land use and land cover [29]. Geospatial techniques primarily provide a complete depiction of the spatial extent of land use and land cover at a specific location and period [30,31]. Mapping and monitoring LULC is necessary to preserve the current natural resources and comprehend the causes and effects of overexploitation of soil and water resources [29].

LULC maps are essential for developing, managing, and monitoring programs at the local, state, and national levels [29]. On the one hand, this type of information aids in the understanding of land use issues, and on the other, it aids in the formulation of policies and programmes necessary for development planning. LULC maps are extremely useful for assessing changes in our environment and ecology. We can create policies, plans, and programs to protect the environment if the research organization is aware of the precise uses of LULC [32,33].

Table No 2.1. Land use and Land Cover (Area in hectares)

LULC	Open	Land with scrub	Kharif + Rabi (Double Cropped)	Kharif
Kumshet	370.09	448.4	62.73	63.35
Kothale	29.5	150.59	24.33	6.74

Table No 2.2. Land use and Land Cover (Area in hectares)

LULC	Dense / Closed	Scrub Forest	Habitation	Water body
Kumshet	2023.53	1.81	0.85	14.21
Kothale	557.12	-	3.23	25.73

The maps no 7 and 8 show that most of the study area is covered by dense forest, Kumshet 2023.53 hectares, and Kothale 557.12 hectares. The land in the Kumshet village LULC included 448.4 hectares of scrub, 62.73 hectares of double-cropped kharif and rabi crops, 63.35 hectares of kharif, 1.81 hectares of scrub forest, 0.85 hectares of habitation, and 14.21 hectares of water body. The Kothale village had 29.5 hectares of open land, 150.59 hectares of land with scrub, 24.33 hectares of double-cropped land used for kharif and rabi seasons, 6.74 hectares of kharif, 557.12 hectares of dense vegetation, 3.23 hectares of habitation, and 25.73 hectares of water bodies [31].

5.6. Ground Water Level

Groundwater is a vital natural resource for drinking, irrigation, agriculture, and industry, as well as supporting human health and the economic development of both rural and urban areas [34,35,36]. Surface water infiltration is dependent on the type of soil strata that supplies groundwater [34]. Compared to soft rock aquifers with high yield capacity, hard rock terrain possesses a limited quantity and is mostly concentrated in the weathered zone and fractured zone [35]. The slope is an essential component in delineating the groundwater potential zone because it can have an immediate effect on surface runoff and infiltration [35,37,38].

Sustainable groundwater development and management necessitate an assessment of groundwater availability, current utilization, and the balance of resources for future use [39]. LULC, geology, geomorphology, and terrain characteristics are also helpful in management, planning, and groundwater issues. Geospatial techniques can help store and conserve groundwater resources [34]. This study facilitates the efficient exploration of scenarios for the planning of groundwater resources in the future. Proper groundwater exploration, management, consumption, and conservation necessitate the use of a variety of techniques and methods, such as groundwater recharge (water harvesting), CCT, dams, revisovers, and so on [34,40]. In such a situation, the proper identification of the potential zones is necessary to prevent financial loss and wasting time and effort [41,42,45]. We can understand geological, hydrogeological, and geophysical aquifer characteristics to enable this type of accurate identification.

The findings of the field survey unequivocally indicated that groundwater is scarce throughout the summer. The area's basalt rock cover, heavy rainfall, and steep slope make water percolation relatively low. In Kumshet village, there are 1329.63 hectares of moderate to poor groundwater level and 1640.11 hectares of poor to nil groundwater level. The ground water level in Kothale village is 494.38 hectors (poor to nil), 154.66 hectors (poor), and 119.24 hectors (moderate to poor) (maps 9 and 10).The villages struggle to supply clean drinking water, household use, and irrigation. The groundwater level maps assist in comprehending the geological structure, which in turn aids policymakers in implementing watershed management and water harvesting planning.

5.7. Soil Erosion

Soil erosion is one of the main environmental issues; it is critical to identify areas that are likely to suffer substantial soil erosion in order to effectively manage different land uses [43]. Soil erosion affects not only nutrient loss, siltation in water bodies, and soil productivity [44], but also public health and the way of life for marginalized populations around the world who primarily depend on agriculture [43,45]. Erosion decreases the organic nutrients, humus, and topsoil in soil, deteriorating its physical, chemical, and biological properties and rendering it unsuitable for crop growth. Anthropogenic disturbances are the main reasons for the high rate of soil loss [43,46]. Soil erosion is nevertheless a major problem that affects agricultural production [47]. Researchers and policymakers typically encounter significant challenges when addressing soil erosion in hilly and mountainous terrain due to the challenging topography and the lack of comprehensive data on the elements that contribute to soil erosion [48].

In the study area, there has been an enormous amount of soil erosion. Kumshet village has 2867.37 hectares of very severe soil erosion, 95.35 hectares of severe to very severe soil erosion, and 7.19 hectares of moderate to severe soil erosion. The Kothale village has 743.67 hectares of very severe and 24.61 hectares of severe to very severe soil erosion (Map No: 11 and 12). Geospatial tools have analyzed the soil erosion area, and these results will help implement soil conservation techniques. The action plan for sustainable development planning recommends these techniques.

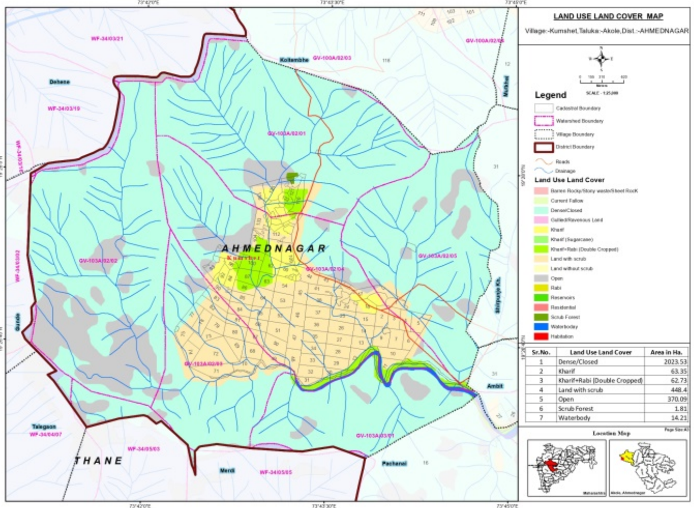


Figure No 7. LULC _ Kumshet

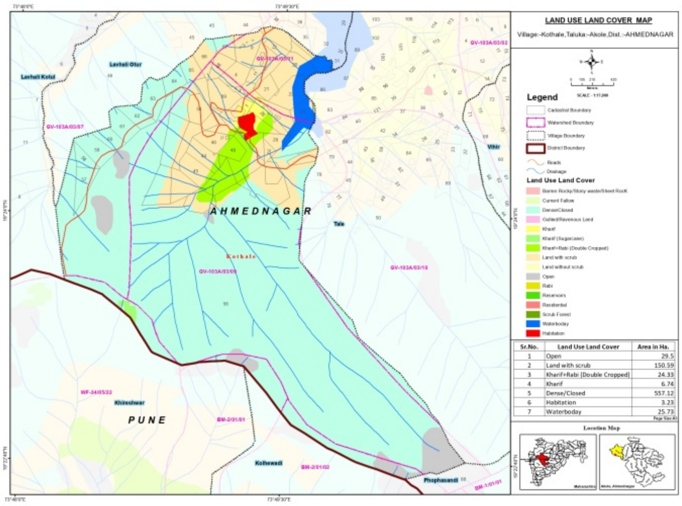


Figure No 8. LULC Map_ Kothale

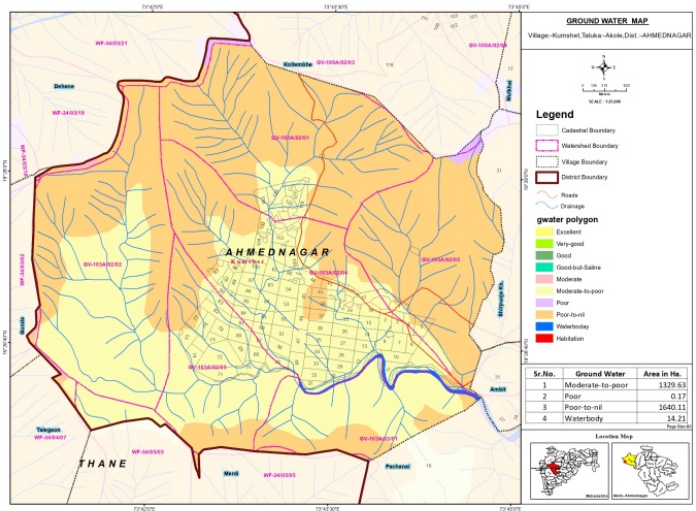


Figure No 9. Ground Water Level-Kumshet

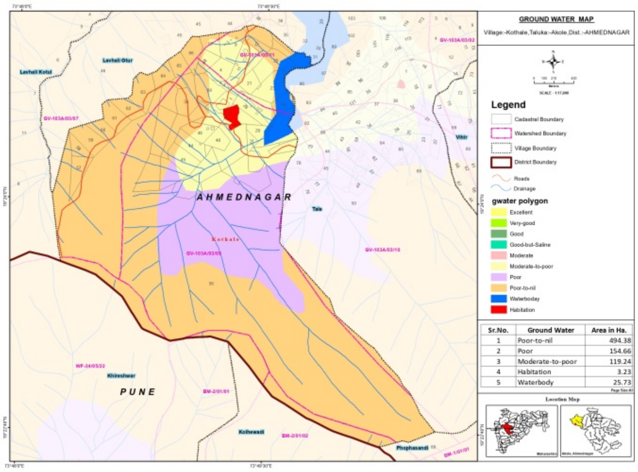


Figure No 10. Ground Water Level_Kothale

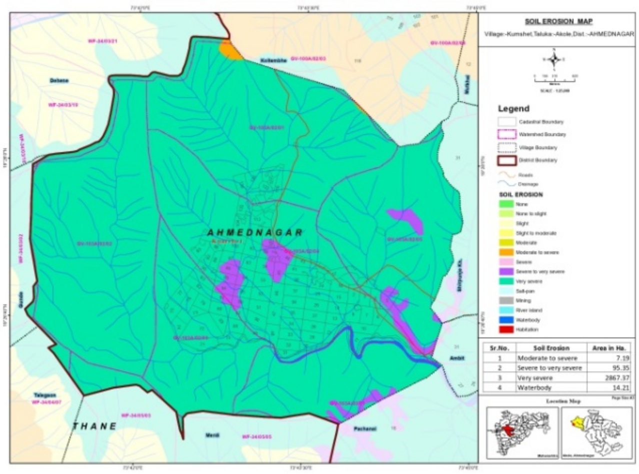


Figure No 11. Soil Erosion Map _Kumshet

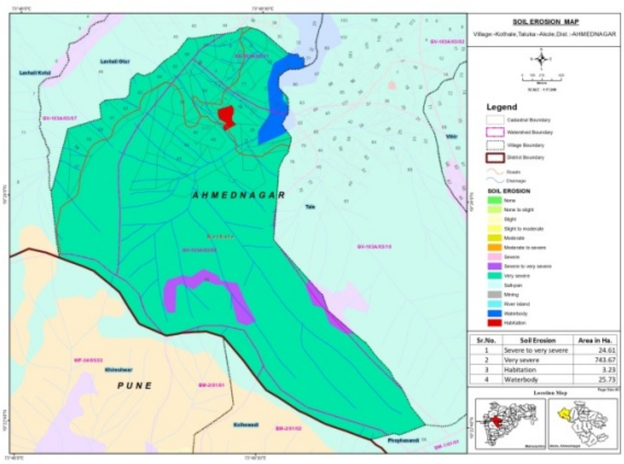


Figure No 12. Soil Erosion Map _Kothale

5.8. Soil Depth

Soil depth is defined as the distance from the surface to roughly consolidated material [49]. Soil depth influences water retention and healthy root development in crops [50,51,52]. Soil depth changes as a result of many variables, including slope, land use, curvature, parent material, weathering rate, climate, vegetation cover, upslope contributing area, and lithology [53,54,55]. Deeper soils are essential for the suggested methods of rainwater collection (rainwater harvesting) because they hold more water and provide nutrients that promote plant development [52,56].

The soil profile's depth reaches the parent material, bedrock, or the layer of root obstacles below the surface. It differs significantly depending on the type of soil. There are four classifications for soil depths: very shallow (less than 10 cm), shallow (10 to 25 cm), moderately deep (25 to 50 cm), deep (50 to 100 cm), and very deep (greater than 100 cm). The soil depth in Kumshet village is 7.19 hectares of very shallow (less than 10 cm), 95.35 hectares of shallow to very shallow (10 to 25 cm), and 2867.37

hectares of moderately deep (25 to 50 cm). The Kothale village area consists of 24.61 hectares of shallow to very shallow (10 to 25 cm) and 743.67 hectares of moderately deep (25 to 50 cm) (Map No 13 and 14).

5.9. Soil Texture

It is important to know the texture of the land because it affects how the soil breaks down and how water moves through it. It also affects how productive and healthy the soil is, how much water and nutrients it can hold, how well it keeps pollutants in, how roots grow, how diverse the soil is, how fast water moves through it, how much it drains, how biogeochemical cycles, and how much it washes away [57,58,59,60,61,62]. Fluctuations in soil texture and profile result in variations in the soil properties, which include root development, growth, and aboveground vegetation [62,63]. The proportion of sand, silt, and clay in the soil determines its texture, which in turn determines almost all other attributes [64,65,66]. Soil texture is critical in determining how agricultural practices and land use changes affect the soil's properties [67,68,69]. For that reason, accurate knowledge of the geographic distribution of soil texture is essential for hydrological planning, environmental preservation, and sustainable agricultural management[70,71,72,73].

The research region's soil textures are gravelly sandy loam and gravelly loam. Kumshet's soil texture consists of 2867.37 hectares of gravelly loam and 102.54 hectares of gravelly sandy loam. Kothale's soil texture consists of 743.67 hectares of gravelly loam and 24.61 hectares of gravelly sandy loam. In both communities, the predominant soil type is gravelly loam (Map No 15 and 16).

5.10. Soil Land Capability

Maps of land suitability and capability are useful tools for conserving soil resources. The soil's ability to sustain the growth of grazing plants and cultivated crops over a long period of time without degradation is known as land capability [74,75]. Land suitability, closely associated with land capability, is defined as the soil's ability to sustain cultivated plants and their yields in a sustainable way [76,77]. The purpose of sustainable land management is to strike a balance between the usually conflicting goals of preserving environmental sustainability and quality and promoting economic growth [78].

The ability and suitability of the soils under classification determine both food production and the preservation of natural resources [79,80]. The land capability classification, which considers various soil properties, associated land features, and environmental variables like climate, indicates a specific area of land's suitability for agriculture and other purposes [81]. Land capability is the foundation for sustainable watershed development. The classification of land capability indicates the hazards of soil and water erosion, water logging, land degradation, and so on, which limit the use of land for specific purposes only [82]. The first four classes are suitable for agriculture; nevertheless, due to usage restrictions and the requirement for conservation measures, a careful management increase is necessary from I to IV. The remaining four categories, V to VIII, can be utilized for grazing, range, pasture, woodland, and wildlife purposes, but they have yet to be used for agricultural purposes (flow diagram 1 and 2) **[82]**. Land planners, resource managers, and policymakers can make informed choices by using land capacity classification as an essential tool to evaluate the potential applications and constraints of land for various reasons.

The only three classes identified in the study area were VI, VII, and VIII. Despite the potential small risks, forestry and grazing should utilize Class VI soil due to its unique characteristics. They are steep or shallow, have moderate permanent limits, and are not ideal for agriculture. When used for forestry or grazing, Class VII soils are permanently restricted or present serious hazards. They can be swampy, dry, eroding, steep, or shallow. Since they are either fair or poor for forestry or grazing, they require careful treatment. Class VIII soils are coarse, even for grazing or wooded areas. Watersheds should be used for recreation or wildlife.

The Kumshet villages are 2867.37 hectors in area VIII, 7.19 hectors in area VII, and 95.35 hectors in area VI in terms of soil land capability class. The soil-land capability classes VI and VIII are only available in Kothale village. The soil and land capabilities of the Kumshet and Kothale villages are suitable for pasture, grazing, wildlife, and watersheds (Map No 17 and 18).

5.11. Sustainable Development Plan (Action Plan)

Cadastral, contour, slope, land use, land cover (LULC), ground water level, soil erosion, soil depth, soil texture, and soil land capacity maps are important aspects of sustainable development planning. These elements all give background information about a specific area, which helps decision-makers make an appropriate decision. After carefully examining the aforementioned elements, researchers developed action plans to help in the sustainable development of tribal villages. These action plans contribute significantly to the conservation of natural resources, provide economic benefit to local communities, and assist policymakers.

Heavy rainfall and a steep gradient in the villages of Kumshet and Kothale pose challenges due to soil erosion during the rainy season and water scarcity during the summer. For this reason, a multitude of techniques for conserving soil and water are useful, such as gully plugs, loose boulder structures (LBS), *cement nalla bandh* (CNB), gabian bandhara, earthen Nalaa bund, and *Kolhapur type bandhara* (KT Weir). The investigators identified sites and locations for implementing conservation methods based on fieldwork and geospatial techniques. The area treatment will enable a variety of activities, including afforestation, dry land horticulture, planation, CCT, deep CCT, forest ponds, compartment and graded bunding, farm ponds, dry land agriculture, and well recharge (Map No 19 and 20). These methods are also beneficial for the tribal people's natural resource conservation and economic development.

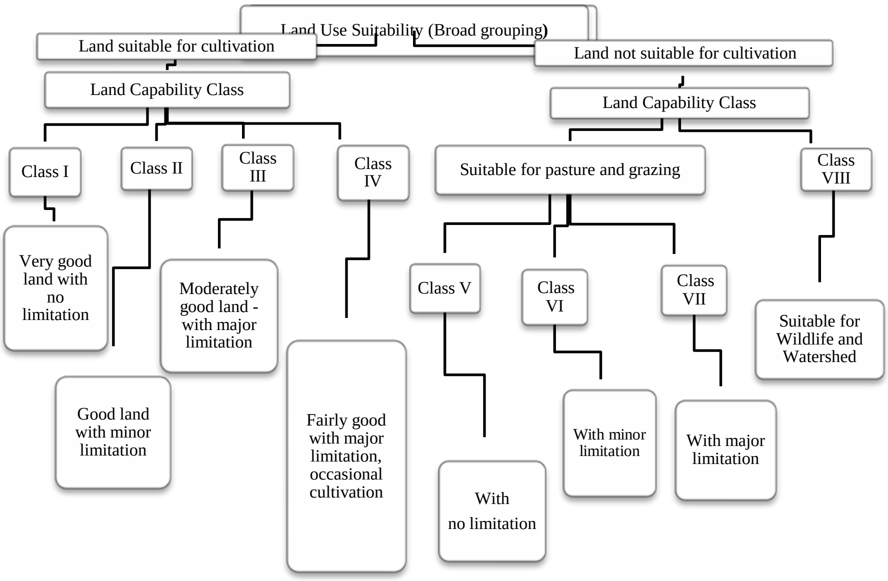


Figure No 1. Land Capability Classification system

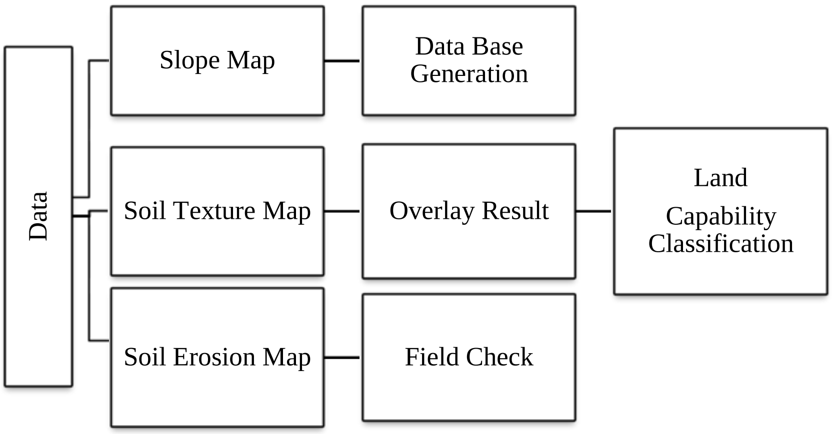


Figure 2. Land Capability classification

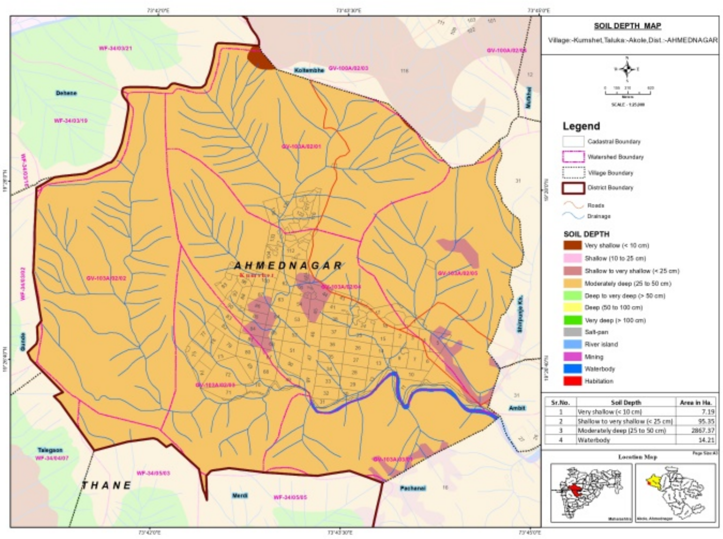


Figure No 13. Soil Depth Map _Kumshet

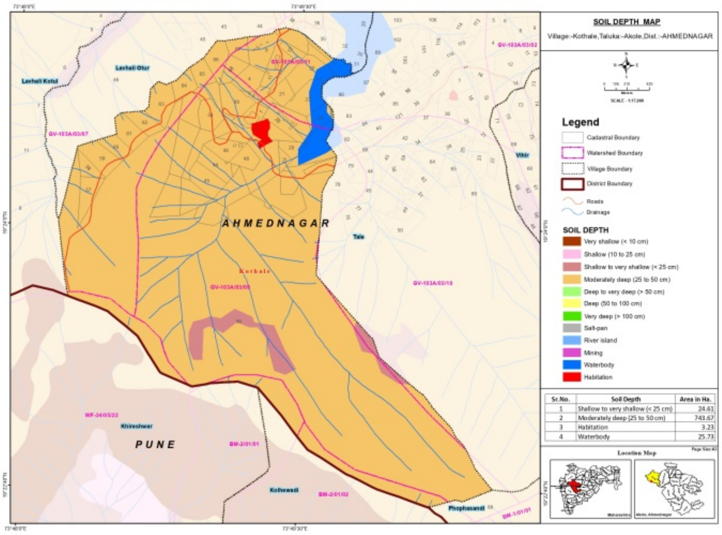


Figure No 14. Soil Depth Map _Kothale

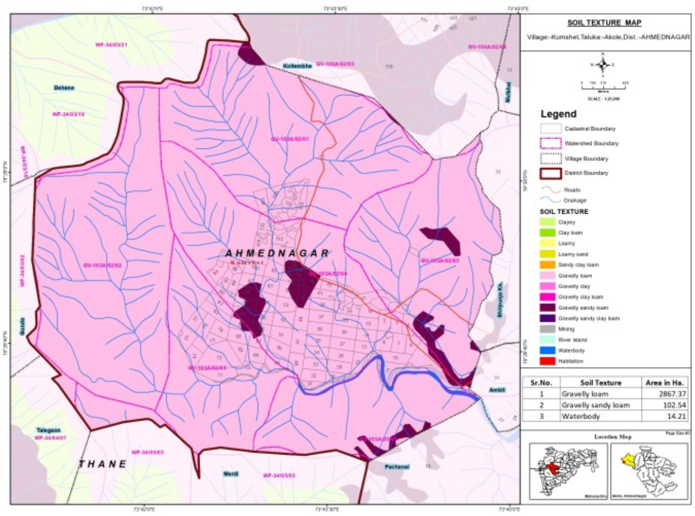


Figure No 15. Soil Texture Map _Kumshet

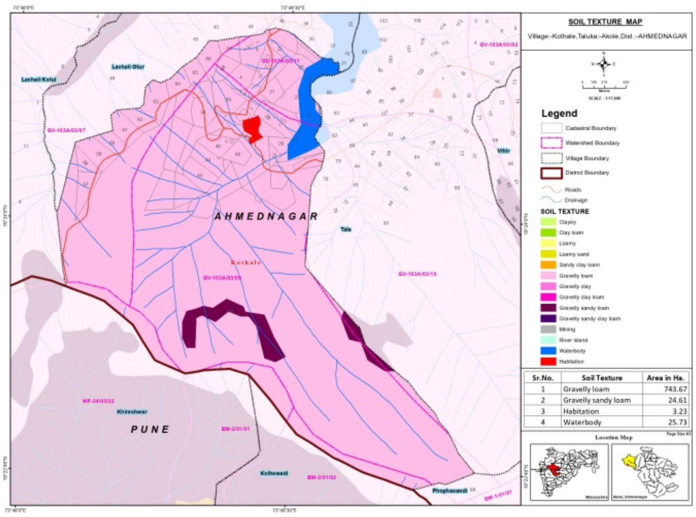


Figure No 16. Soil Texture Map _Kothale

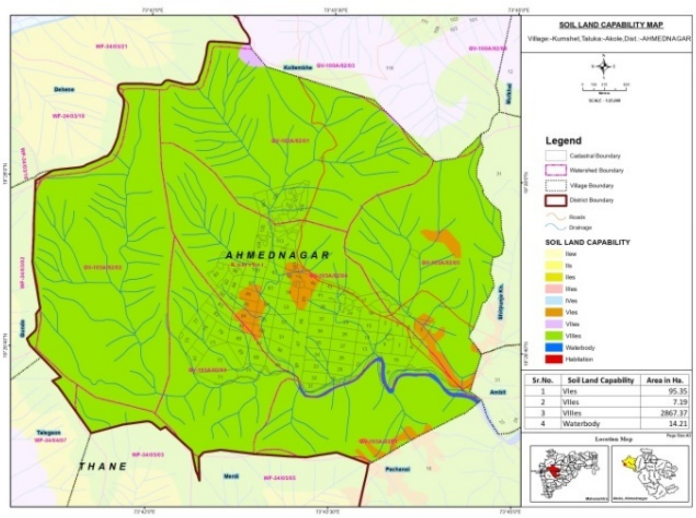


Figure No 17. Soil Land Capability_Kumshet

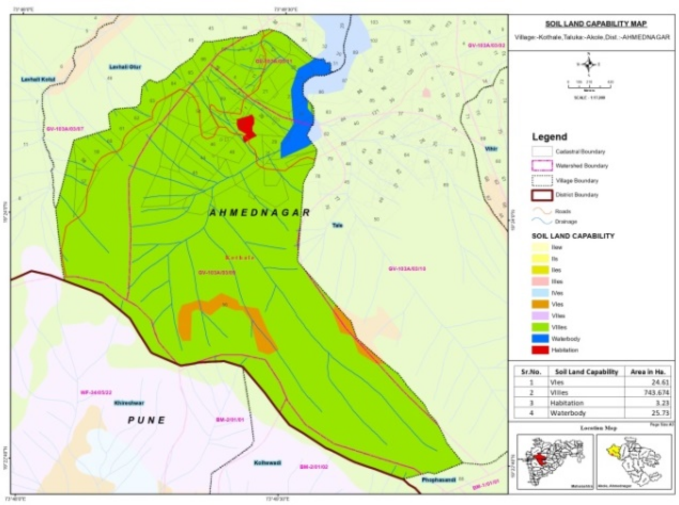


Figure No 18. Soil Land Capability Map_Kothale

5.12. Tourism Sites

The Kothale village has several locations that would be ideal for tourism development. Untouchable and well-known tourist destinations near the village include sacred groves (*Ban/Devrai)*, the pass (*khind)*, the fort (*Gad*), many waterfalls, *Bohda*, fireflies, and so on. The development of tourist destinations will promote tourism, which will support tribal areas' economic growth. Certain sacred groves, such as *Vaghoba Ban*, *Kaloba Ban, Satiaai Ban*, and *Pautaka Ban*, symbolize the beliefs, cultural traits, and customs of tribal communities. The *Bhairavgadt*, situated 3464 feet to the west of the village, is a trekking destination in the western ghat. One of the pathways to Harishchandragad is the *Tolarkhind* (pass), which attracts tourists due to its geographical location. During the rainy season, numerous waterfalls cascade around the area, which attracts tourists (Map No 22).

5.13. Landslide area

The village experiences frequent landslides due to the hill ranges, heavy rainfall, and steep slope elements. GIS uses factors like elevation, lithology, slope, land use, rivers, streams, topographical moisture index, road, fault, and precipitation to pinpoint the villages' land slide locations. This makes it possible to identify the landslide area and implement preventive measures (Map No 22).

5.14. Human Wildlife Conflict Mitigation

Human-wildlife conflict refers to the interaction between humans and wild animals those results in negative impacts on both sides. Kothale village is located in the KHWS, part of the Western Ghat. Kothale has a substantial community of individuals who have traditionally engaged in agricultural activities and cattle rearing. Human-wildlife conflicts occur frequently in village areas, necessitating the development of action plans to reduce their severity [31].

Leopards, wild boars, bears, and snakes were responsible for most of the injuries in the study area. The frequency of wild boar attacks on farm guards at night has increased, particularly during harvest season and livestock grazing periods near forests and roads. These attacks are a result of human encroachment on wild animal habitats. The leopards attack the livestock near a forest area during grazing time at night. We have prepared the plan of action using data collected through field visits, GPS data, the Survey of India Toposheet, and discussions with numerous individuals, including groups, forest departments, and cowherds.

The map no. 21 also indicates the various action plans to reduce the HWC in the study area. The identification of the corridor's geographic region took into account the presence of accessible wildlife, dense vegetation, and topography. Wildlife corridors, located far from human activities, promote minimal harm to the natural habitat of wild animals. Water is also one of the basic needs of wild animals. Villagers had the opinion that wild fauna frequently ventured into human settlements in pursuit of sustenance and water. Therefore, it is important to identify a suitable site for water sources and construct man-made water tanks, such as the KT Weir (*Kolhapur Type Bandhara*) and *Panavath*. The village region has hilly terrain and abundant rainfall, which accentuates the presence of natural springs as sources of water. One of the significant suggestions was to construct the observation tower in suitable locations to carry out observations of wild animal movements. This action plan is also helpful for the sustainable development of tribal villages, the conservation of natural resources, and reducing the conflict between nature and humans. These action plans will guide the achievement of the Sustainable Development Goals. The study of local geographical factors is essential for development planning, as it significantly contributes to the effective implementation of policies and programs.

6. Conclusion

Tribal villages in KHWS should be developed with an emphasis on enhancing the socioeconomic circumstances of the local populations while conserving the environment.This can be accomplished by creating a sustainable development plan that takes into account the area's natural resources, which are integral to the livelihoods, culture, and survival of indigenous communities. The KHWS abundant natural resources, such as forests, water bodies, land, and biodiversity, are essential for maintaining ecological balance as well as the traditional means of subsistence for the local tribes.

A sustainable approach should integrate eco-friendly practices such as agroforestry, organic farming, responsible tourism, and handicrafts, promoting community-led initiatives and leveraging traditional knowledge; these villages can achieve self-sufficiency while preserving their rich biodiversity and cultural heritage, ensuring that economic development does not compromise the sanctuary’s delicate ecosystem. Collaboration between the community, NGOs, and government agencies is crucial for effective policy implementation and for ensuring that development efforts in the tribal village of the sanctuary serve as a model for sustainable rural development.

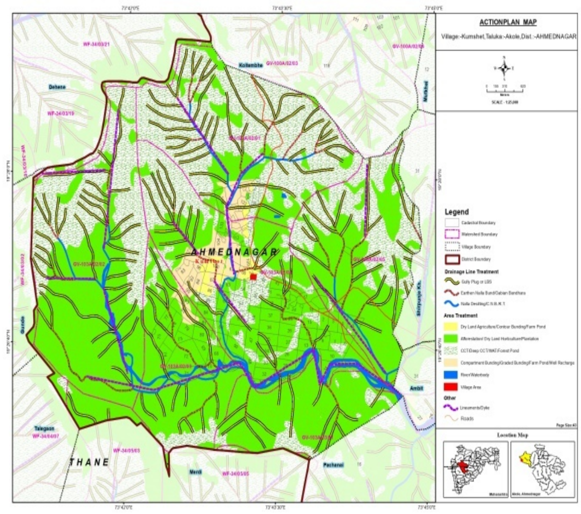


Figure No 19. Action Plan_Kumshet

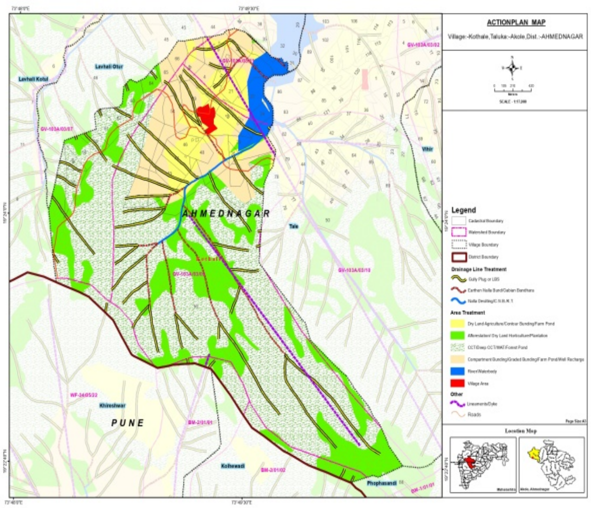


Figure No 20. Action Plan_Kothale

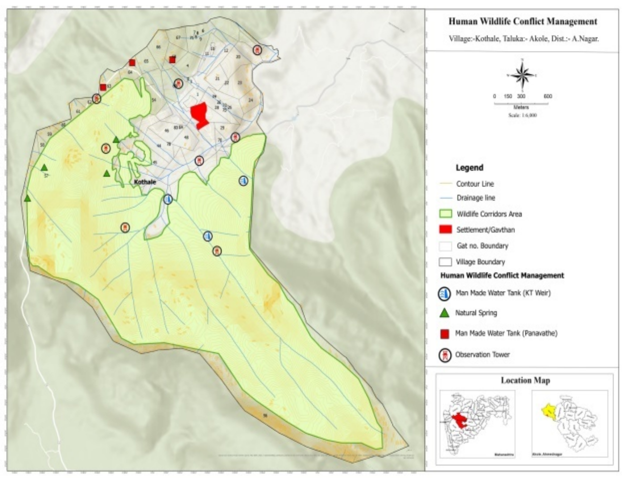


Figure No 21. HWC Mitigation Plan_Kothale

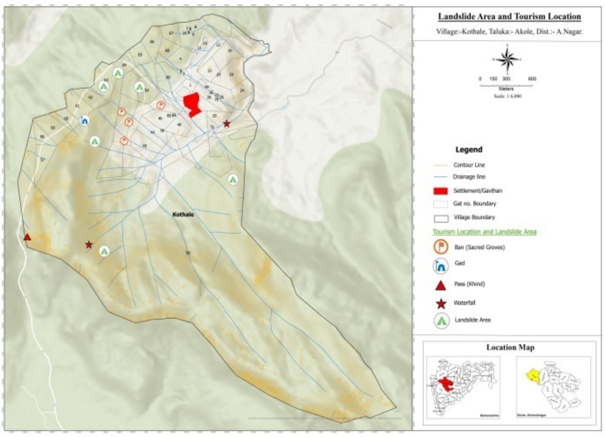


Figure No 22. Landslide &Tourism Plan_Kothale

ACKNOWLEDGEMENTS

The authors are grateful to the Internal Quality Assurance Cell (IQAC), Savitribai Phule Pune University, for their financial support under the Aspire Research Mentorship Grant (Sanction Letter Number 20TEC000973).The authors extend their gratitude to Shikshan Prasarak Sanstha Sangamner Nagarpalika Arts, D.J. Malpani Commerce, and B.N. Sarada Science College (Autonomous), Sangamner, as well as the Department of Geography at Savitribai Phule Pune University for providing the necessary technical and other facilities to conduct this research work. We are also grateful to the Kalsubai Harishchandragad Wildlife Sanctuary Department for providing the required data. The author also thanks the anonymous reviewers for their comments and suggestions, which helped improve the quality of the manuscript.

Competing Interests

The author declares that they have no competing interests.

Authors' Contributions

Both authors collaborated to carry out this work. Author Sandip Deshmukh designed the research work, managed the literature review, conducted field surveys, data analysis, GIS mapping, and wrote the first draft of the manuscript. Author Dr. Ravindra Jaybhaye developed the conceptual framework, supervised the research work, and reviewed the final manuscript. All authors read and approved the final manuscript.

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