

Sustainable Development Planning for New Mahabaleshwar Hill Station Area of Mahabaleshwar, Jaoli, Satara & Patan Taluka's in Satara District, Using Geospatial Technology.

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Abstract

The New Mahabaleshwar Hill Station Area Development Plan addresses the challenges of promoting sustainable development in one of India's most ecologically sensitive regions, the Western Ghats. Spanning 235 villages in Satara, Jaoli, Patan, and Mahabaleshwar talukas, the plan integrates Geographic Information System (GIS)-based methodologies with detailed demographic, economic, and environmental analyses. The objective is to achieve balanced development that fosters economic growth, preserves biodiversity, and improves the quality of life for local communities.

The plan identifies existing issues such as deforestation, human-wildlife conflicts, inadequate infrastructure, and tourism pressures. It proposes sustainable solutions through strategic land-use zoning, infrastructure development, and environmental conservation. Key focus areas include improving connectivity through innovative transportation systems, addressing housing and socio-economic needs, and leveraging the region's tourism potential while adhering to eco-sensitive norms. The plan also emphasizes disaster management strategies to mitigate risks from earthquakes, floods, and landslides.

Tourism is positioned as a driver of inclusive growth, with proposals for community-based eco-tourism, heritage conservation, and carrying capacity assessments to ensure sustainable visitor management. Environmental preservation is prioritized through initiatives like protected zones, green infrastructure, and renewable energy projects.

This paper highlights the integration of data-driven approaches with participatory planning to ensure compliance with the Maharashtra Regional and Town Planning (MRTP) Act, 1966, AMRUT guidelines and Maharashtra State Government Resolution. The proposed development strategies aim to create a blueprint for sustainable progress that safeguards the region's unique ecological and cultural heritage.

Keywords: Aerial Survey, Cluster-based Approach, DGPS, GIS, LiDAR Technology, Remote Sensing, Sustainable Development, Tourism Development, Western Ghats Eco-Sensitive Area.

1. Introduction

The New Mahabaleshwar Hill Station Area Development Plan represents a critical initiative to address the challenges of sustainable growth in an ecologically sensitive region. Located in the Western Ghats of Maharashtra, this area encompasses 235 villages in Satara, Jaoli, Patan, and Mahabaleshwar talukas, in Satara District covering approximately 1,153 sq.km. Renowned for its biodiversity, cultural heritage, and tourism potential, the region faces pressing issues such as environmental degradation, human-wildlife conflicts, inadequate infrastructure, and socio-economic disparities.

As per the Maharashtra Regional and Town Planning (MRTP) Act, 1966, aligned with Atal Mission for Rejuvenation and Urban Transformation (AMRUT) guidelines and Maharashtra State Government Resolution, the development plan employs Geographic Information System (GIS) technologies to integrate spatial and attribute data for effective decision-making. The objective is to balance conservation priorities with economic and infrastructural development, ensuring long-term sustainability.

The plan envisions addressing core challenges, including deforestation, unplanned urbanization, hilly area and strained resources, by promoting sustainable land-use practices, eco-friendly infrastructure, and community-based tourism. It emphasizes participatory planning to engage local stakeholders and foster inclusive growth. Key components include upgrading connectivity, enhancing socio-economic conditions, preserving natural and cultural heritage, and implementing robust disaster management strategies.

This paper delves into the region's unique geographic and demographic profile, outlines existing issues, and discusses proposed interventions. The overarching goal is to create a blueprint for development that respects the region's ecological fragility while enabling progress. By integrating technology, policy, and community participation, the plan aims to secure a sustainable future for the New Mahabaleshwar Hill Station Area.

2. Literature Review

The Mahabaleshwar region, located in the Western Ghats of Maharashtra, has been the focus of numerous studies and reports examining its socio-economic development, environmental conservation, and potential for sustainable tourism. These studies emphasize the unique biodiversity of the area, the pressures of urbanization, and the opportunities for enhancing local livelihoods through responsible development.

Ecotourism in Mahabaleshwar and Panchgani (Woods, 2005) Woods (2005) examines the potential for establishing ecotourism in Mahabaleshwar and Panchgani, two of the region's most popular hill stations. Ecotourism is seen as a means of promoting conservation while simultaneously supporting the local economy. The study advocates for responsible tourism practices that minimize environmental impact while allowing visitors to appreciate the region's unique natural beauty and cultural heritage. Ecotourism can create a sustainable economic model by involving local communities in tourism activities, creating jobs, and generating revenue that can be reinvested in conservation efforts.

Environmental Sensitivity and Regional Planning (UDD, GoM, 2015) The Government of Maharashtra (GoM) has taken steps to ensure that Mahabaleshwar and Panchgani are preserved as ecologically sensitive zones (ESZ), as outlined by the UDD, GoM (2015). The declaration of these areas as ESZs aims to protect the biodiversity and natural resources from the adverse effects of unregulated development. The Regional Planning Board's role in developing plans that integrate conservation and development is essential in maintaining the delicate balance between growth and environmental preservation. This policy is vital for ensuring that tourism, agriculture, and other industries do not compromise the environmental integrity of Mahabaleshwar, allowing for sustainable development in the region.

Socio-Economic Development in Mahabaleshwar and Jaoli Tehsil (Suryawanshi, 2017) Suryawanshi (2017) explores the socio-economic dynamics of Mahabaleshwar and the adjacent Jaoli Tehsil. The study highlights the role of agriculture, tourism, and local industries in shaping the livelihoods of residents. Agriculture, particularly the cultivation of strawberries, is a key economic activity, while tourism also plays an important role in the economy of the region. However, the rapid urbanization and growing population in Mahabaleshwar have created challenges related to infrastructure development, resource management, and the

provision of services to a diverse population. The research underscores the need for balanced development strategies that preserve the ecological integrity of the region while addressing the demands of a growing population.

Spatio-Temporal Perspectives of Wind Power in Satara (Pawar et al., 2020) In recent years, the region's potential for renewable energy, particularly wind power, has become a subject of study. Pawar et al. (2020) focus on the spatio-temporal aspects of wind energy in Satara, which encompasses Mahabaleshwar. The study identifies areas with high wind potential, which could support the development of wind farms. The development of wind power in the region is crucial as it provides an alternative to traditional energy sources, supports sustainable development, and reduces the region's carbon footprint. This shift towards renewable energy can also contribute to the local economy by creating job opportunities and reducing dependency on fossil fuels.

Evaluation of orchid species from Mahabaleshwar Plateau of Western Ghat (DS Kadam, M. S. 2022) Evaluation of orchid species from Mahabaleshwar Plateau of Western Ghat, conducted a detailed evaluation of orchid species from the Mahabaleshwar Plateau, located within the Western Ghats. Their study highlights the rich biodiversity of the region, focusing on the identification and classification of various orchid species found in this ecologically sensitive area. The research contributes to understanding the floral diversity of the plateau, emphasizing the importance of preserving these species in the face of growing developmental pressures. This work is significant for conservation efforts, as orchids are vital indicators of environmental health in the Western Ghats ecosystem.

Koyna Dam and Its Impact on the Region (Wikiwand, 2023) The Koyna Dam, located in the vicinity of Mahabaleshwar, plays a significant role in the region's water supply and energy generation. According to Wikiwand (2023), the dam has provided vital irrigation and drinking water to the surrounding areas and is a critical source of hydroelectric power. However, the dam's construction and its impact on local ecosystems, including changes in water quality and availability, are points of concern. Balancing the benefits of the Koyna Dam with the need to preserve the natural environment, particularly the wildlife in the Sahyadri Tiger Reserve and surrounding forests, remains an ongoing challenge.

Flora and Fauna of Mahabaleshwar (Deshpande, N.D.) The biodiversity of Mahabaleshwar is a key feature of its ecological and cultural importance. Deshpande (n.d.) in *Flora of Mahabaleshwar and Adjoining's* provides an extensive catalog of the plant species found in the region, focusing on the unique flora that thrives in the area's diverse ecosystems. The region is home to numerous species of medicinal plants, orchids, and other endemic species, many of which are critical to maintaining the region's ecological balance. The preservation of this biodiversity is integral not only to environmental conservation but also to local socio-economic development, as many of these plants contribute to local economies through tourism and traditional medicine.

3. Regional and Geographic Context

The New Mahabaleshwar Hill Station Area, spanning 235 villages across Satara, Jaoli, Patan, and Mahabaleshwar talukas, is situated in the ecologically sensitive Western Ghats, a UNESCO World Heritage site. This region's strategic location in the Deccan Plateau, lies between longitudinal extent 73° 33' 52.11" to

73° 56' 48.25" and latitudinal extent 17° 54' 28.16" to 17° 8' 42.82" with proximity to major national highways NH-66 (Mumbai-Goa-Kanyakumari) and NH-48 (Delhi-Chennai), enhances its connectivity to urban centers while offering significant potential for eco-tourism and regional development.

The area is characterized by diverse geographical features, including rugged terrain, dense forests, rivers, waterfalls, and plateaus. It lies within the Krishna and Koyna river basins, supporting rich biodiversity and vital ecological functions. The agro-climatic conditions range from temperate to tropical, providing opportunities for agriculture, horticulture, and agro-tourism. However, this diversity also makes the region susceptible to environmental degradation and natural disasters like floods, landslides, and earthquakes.

The delineated area is part of several eco-sensitive zones, including the Sahyadri Tiger Reserve, Koyna Wildlife Sanctuary, and Chandoli National Park, underscoring the need for stringent environmental safeguards. The Western Ghats' flora and fauna are irreplaceable, with endemic species and critical habitats requiring conservation.

Demographically, the region hosts a predominantly rural population engaged in agriculture and allied activities. Its natural and cultural heritage—encompassing forts, sacred groves, and waterfalls—provides immense tourism potential. Yet, limited infrastructure, poor connectivity, and socio-economic challenges hinder growth. This regional and geographic analysis highlights the dual necessity of preserving the area's ecological richness while addressing its development needs. The development plan proposes strategic interventions to balance growth with sustainability, leveraging GIS tools and participatory planning to ensure inclusivity and resilience.

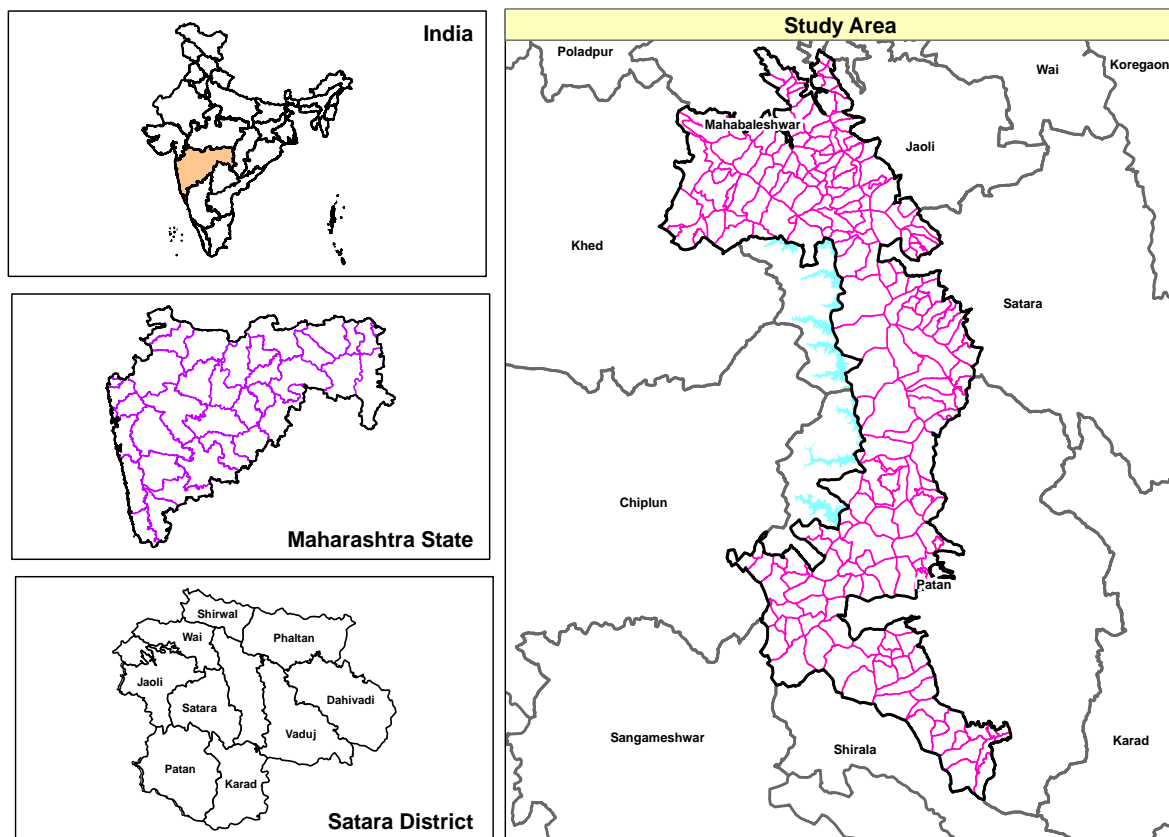


Fig. No. 1 Location map of Study Area

4. Database and Methodology

Data Collection and Integration

The focuses on collecting and integrating data to preparation of development plan includes:

- The process begins with the collection and analysis of primary, secondary, and tertiary data. Primary data is gathered through field surveys, Socio-economic surveys, public consultations, and stakeholder meetings, focusing on land use, infrastructure, and socio-economic conditions.
- Remote Sensing / Aerial Imagery: High-resolution satellite imagery / aerial surveys, supported by LiDAR technology, are used to capture the topography, landuse and land cover, and other spatial attributes of the region.
- Revenue Data: Mapping administrative boundaries, land ownership information through the integration of cadastral / village maps, and land revenue records.
- Secondary data collection include data that is already available with various governmental organizations/agencies at the state and local level. This data included in the forest data, road network information and irrigation/ waterbody data and published reports, statistical abstracts, census reports, information from various line departments, etc.

Methodology

The development of New Mahabaleshwar as a greenfield project is guided by a comprehensive methodology that integrates geospatial technologies, ensuring an innovative, sustainable approach to urban and regional planning. The methodology focuses on creating a balance between ecological preservation, infrastructure development, and socio-economic growth. Geospatial technologies such as Geographic Information Systems (GIS), Remote Sensing, Light Detection and Ranging (LiDAR), Panoramic Imagery are used to map, analyse, for the demographic analysis we are considered the Linear Regression method for the population

projection, and plan the development in line with the strategic goals outlined in the vision. The preparation process complies with the Maharashtra Regional and Town Planning (MRTP) Act, 1966, and aligns with AMRUT guidelines and Maharashtra State Government Resolution, emphasizing modern urban planning tools.

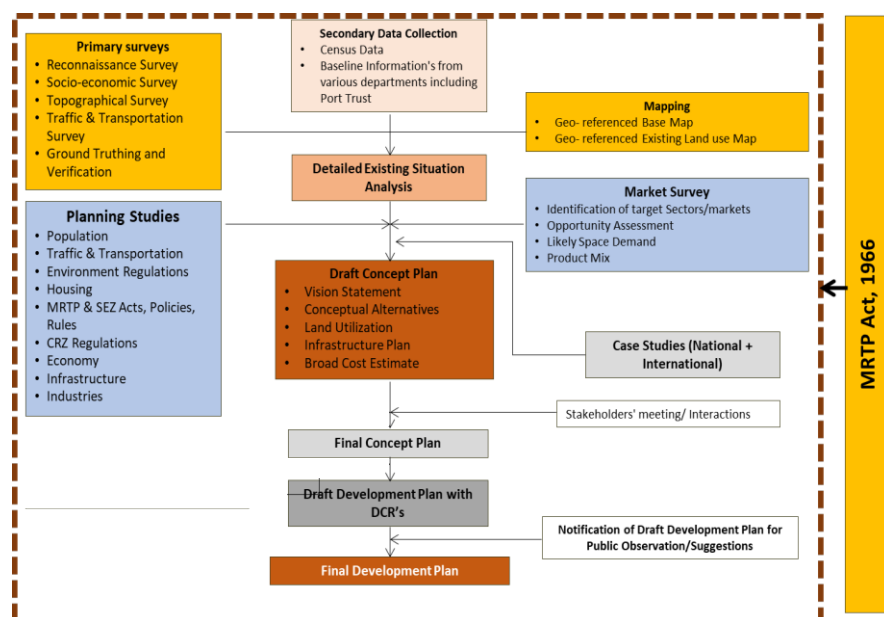


Fig. No. 2 Methodology

5. Result and Discussion

5.1 Socio-Economic and Demographic Insights

The socio-economic and demographic profile of the New Mahabaleshwar Hill Station Area provides a critical foundation for its development plan. As per the 2011 Census, the region has a population of 95,362 distributed across 235 villages in Satara, Jaoli, Patan, and Mahabaleshwar talukas. The population density is relatively low, reflecting the rural and ecologically sensitive nature of the region.

- **Demographics**

The area has witnessed moderate population growth, influenced by migration patterns and natural growth rates. The sex ratio is favorable, with approximately 988 females per 1,000 males. Literacy levels are high, although disparities exist among different villages. The majority of the workforce is engaged in agriculture, followed by small-scale industries and tourism-related activities.

- **Socio-Economic Insights**

Agriculture dominates the economy, with a significant emphasis on horticulture and cash crops such as strawberries and sugarcane. Emerging opportunities in agro-tourism are gaining tourist attraction. Housing in the region predominantly comprises semi-permanent structures, reflecting rural and resource-constrained settings. Demand for affordable housing is expected to grow in tandem with population increases. Limited access to healthcare, education, and other basic amenities hampers socio-economic development. Connectivity and transport issues further isolate many villages, restricting access to markets and services.

5.2. Land Use and Infrastructure Planning

The study area adopts a strategic approach to land use and infrastructure planning, aiming to balance sustainable growth with environmental conservation. The plan covers 115,330 hectares of land, integrating zoning regulations and infrastructure proposals to address current challenges while preparing for future demands.

5.2.1 Existing Land Use (ELU)

The region's existing land use primarily includes agriculture, forests, and settlements. Residential zones are concentrated in village clusters, while significant portions are dedicated to eco-sensitive areas, including forests, water bodies, and conservation zones. The ELU analysis identifies gaps in basic amenities, unplanned expansions, and encroachments into protected areas.

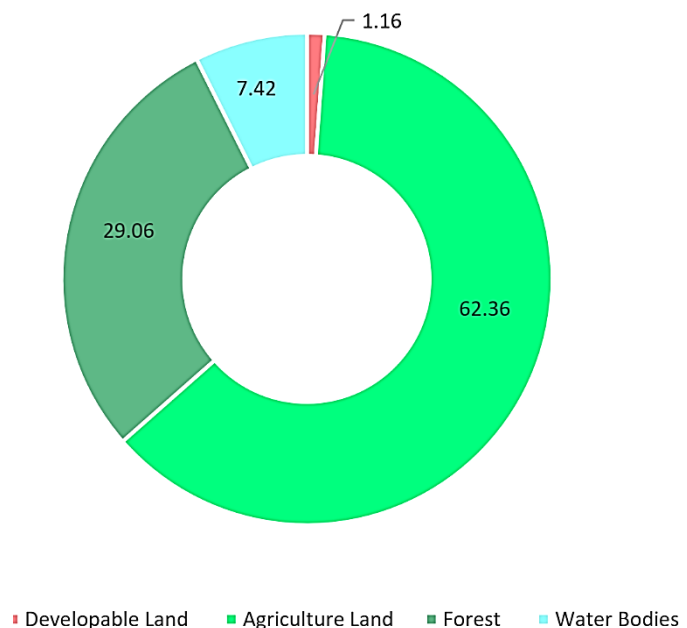


Fig. No. 3 Existing Landuse

5.2.2 Proposed Land Use (PLU)

The proposed land use plan emphasizes:

- **Residential Development:**

The proposed residential zone spans 6.02% of the total area, covering 69.47 sq. km. Residential development will focus on expanding existing settlements, especially near gaothans, with buffer zones of 200-500 meters to protect the environment. This expansion aims to accommodate the growing population while minimizing ecological impact, ensuring sustainable growth that integrates with the region's natural landscape.

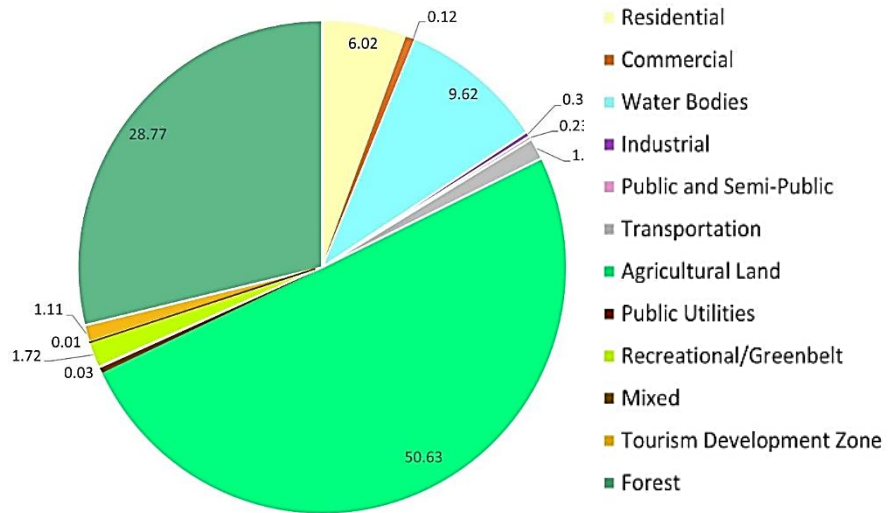


Fig. No. 4 Proposed Landuse

- **Commercial and Industrial Expansion (EPC):**

Commercial areas are proposed to cover 1.37 sq. km (0.12% of the total area), expanding along major roads like NH 166 and SH 58, including adventure tourism, resorts, and home stays. Industrial areas will grow to 3.70 sq. km (0.32%), with a focus on agro-processing, cottage industries, and eco-production centers. These expansions are designed to support both local economies and tourism development while considering environmental constraints.

- **Transportation Infrastructure:**

Transportation areas are expanded to 16.15 sq. km (1.40% of the total area), which includes the development of new roads, cycle tracks, and electric vehicle-friendly infrastructure. This expansion is key to improving accessibility and connectivity for both residents and tourists, with a focus on sustainable transport options, such as eco-friendly last-mile connectivity and green corridors.

- **Recreational and Tourism Development:**

Recreational spaces will grow to 19.88 sq. km (1.72% of the total area), introducing nature trails, hilltop gazebos, and agro-tourism activities like strawberry farms. This initiative aims to enhance the tourism experience, creating spaces for outdoor activities while preserving the region's rich biodiversity. These recreational areas are designed to blend conservation with tourism, creating a sustainable model for the region's future.

- **Utilities and Services:**

Public utility areas will cover 0.40 sq. km (0.03% of the total area), reflecting the significant need for improvements in essential services like water, sanitation, and waste management. Proposed developments include water treatment plants and bio-toilets to address existing infrastructure gaps. The goal is to ensure a

reliable supply of basic services to meet the demands of a growing population and support sustainable urban development

- **Social Infrastructure:**

Social infrastructure, covering areas such as health, education, and community services, will increase significantly, with new facilities like 36 health centers (including hospitals and dispensaries) and educational hubs spread across 77.93 hectares. These developments aim to improve the quality of life for both residents and visitors, ensuring equitable access to healthcare, education, and cultural services in line with population growth

- **Environmental Conservation:**

Forest areas remain a significant portion, with 331.86 sq. km (28.77% of the total area) designated for conservation, including the Sahyadri Tiger Reserve. Additionally, water bodies are allocated 110.97 sq. km (9.62%) with buffer zones to protect water quality. These conservation measures ensure the preservation of critical ecosystems, balancing development with ecological sustainability.

- **Proposed Traffic & Transportation:**

A comprehensive development plan for traffic and transportation in the study area, emphasizes the importance of enhancing connectivity through various modes of transportation, including roadways, railways, airways, and waterways.

Road Connectivity: The plan proposes the widening of existing roads and the introduction of new routes to improve access to remote areas. A total of 378.27 kilometers of new roads are proposed, along with non-motorized transit routes such as cycle tracks and nature trails, aiming to promote sustainable tourism while respecting the ecological sensitivity of the region.

Rail Infrastructure: Currently lacking a functional railway station, Mahabaleshwar will benefit from the establishment of two new stations along a proposed Chiplun-Karad railway line. This initiative aims to facilitate smoother travel for residents and tourists alike, with additional narrow gauge rail routes connecting significant tourist attractions.

Air Connectivity: To boost tourism, expanding air access through new helipads and an airstrip in Baje Village. A seaplane base at Urmodi Dam is also planned to enhance connectivity via waterways, providing a unique travel experience while supporting local economies.

Innovative Transportation Options: The various innovative transportation options such as zip lines and ropeways to enhance the tourist experience while promoting eco-friendly travel. These initiatives aim to connect unexplored destinations within the region, making it more accessible for visitors.

5.3. Tourist Paradise

"Tourist Paradise," outlines a comprehensive development plan for the study Area, focusing on enhancing tourism through a structured "Hub & Spoke" model. This model aims to create Tourism Growth Centres (TGCs) and Tourist Paradises (TPs) that provide seamless travel experiences and promote sustainable tourism.

- **Tourism Growth Centres (TGCs)**

TGCs serve as hubs equipped with modern facilities including theatres, eco-tourism businesses, museums, and eco-restaurants. Initial mobility within TGCs will be restricted to parking areas, promoting pedestrian movement and the use of electric vehicles or animal-based transport.

- **Tourist Paradises (TPs)**

TPs are designed to enhance tourist experiences by providing essential amenities such as registration facilities, safety gear, restrooms, and information. They will ensure connectivity to TGCs through various transport modes including roads, ropeways, and nature trails. The distribution of TPs across several sectors: **Kandat Valley** Focuses on pilgrimage circuits and adventure activities like hot air ballooning and ropeways. **Tapola** Emphasizes connectivity through narrow-gauge rail and water activities on the Koyna reservoir. **Solashi Valley** Proposes ropeways and water activities to enhance accessibility and tourism. **Raj Vaibhav** Highlights adventure sports like ziplining and augmented reality nature walks at Kas Lake. **Bamnoli** A water-centric sector with eco-resorts and wellness retreats. **Urmodi** Combines adventure sports with scenic landscapes, including water-plane landings. **Thoseghar** Known for its waterfalls and adventure tourism like bungee jumping. **Bharsakhale** Focuses on eco-tourism with activities like rappelling near waterfalls. **Aral** Integrates eco-tourism with astronomy-based tourism in a Dark Sky Park setting. A strategic approach to developing the New Mahabaleshwar Hill Station Area as a premier tourist destination. By integrating sustainable practices with modern amenities and diverse tourist activities, the plan aims to enhance visitor experiences while preserving the natural environment. The proposed infrastructure not only facilitates accessibility but also promotes cultural engagement and adventure tourism, making it a holistic development initiative for the region.

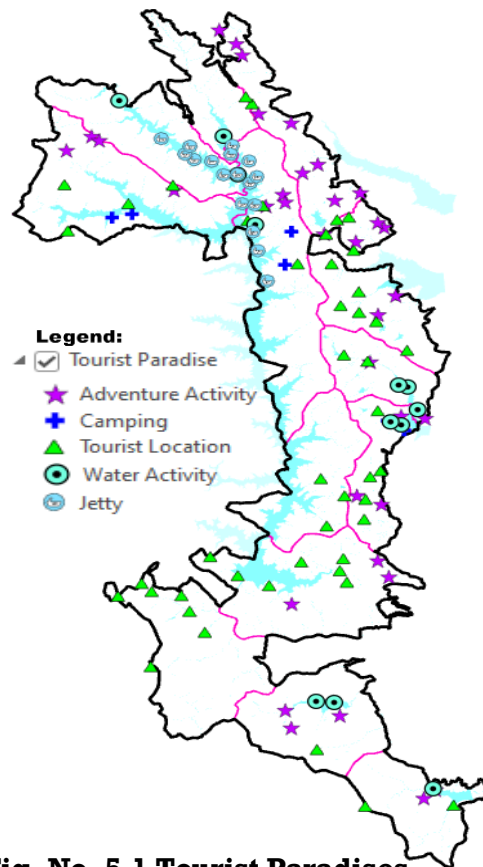


Fig. No. 5.1 Tourist Paradises

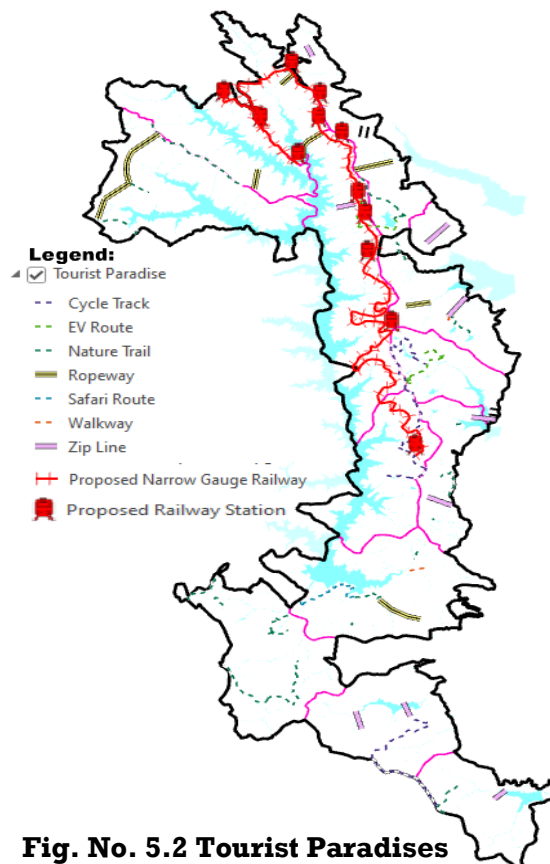


Fig. No. 5.2 Tourist Paradises

5.4. Protection and Conservation of Eco-Sensitive

New Mahabaleshwar Hill Station Area focuses on the critical strategies for the protection and conservation of eco-sensitive areas. It emphasizes the importance of adhering to regulations and restrictions outlined in relevant notifications, particularly those from the Kasturirangan report regarding sacred groves. The study area highlights the need to mitigate human-animal conflicts and environmental damage, aiming for a balanced approach to development that respects ecological integrity. One of the key issues addressed is the fragmentation of tiger movement corridors due to infrastructure developments, such as the NH166 E and the proposed Karad-Chiplun Railway line. This fragmentation threatens wildlife populations by isolating them from essential habitats. To counteract these impacts, the study area strategies for protecting eco-sensitive areas, including the relocation of settlements from critical habitats, the establishment of clear zoning regulations, and the restriction of major tourism activities to buffer zones. Ecotourism initiatives are encouraged to preserve biodiversity while accommodating human needs. Furthermore, the introduction of Non-Motorized Transport (NMT) circuits within Tourist Growth Centres (TGCs) aims to reduce pollution and enhance the tourist experience while protecting the natural environment. A comprehensive framework for the protection and conservation of eco-sensitive areas, balancing development with ecological sustainability and community involvement.

Environmental and Disaster Management

The New Mahabaleshwar Hill Station Area, part of the ecologically sensitive Western Ghats, faces significant environmental challenges. The region's biodiversity, hydrology, and forest cover are under pressure from deforestation, human encroachment, and unplanned development. Additionally, the area is prone to natural disasters such as earthquakes, floods, landslides, and necessitating a robust environmental and disaster management framework.

- **Environmental Management**

Eco-Sensitive Zoning the plan emphasizes protecting eco-sensitive areas, including the Sahyadri Tiger Reserve, Koyna Wildlife Sanctuary, and Chandoli National Park. Strict zoning regulations prevent unplanned expansion and encroachment. Biodiversity Conservation strategies include reforestation, habitat restoration, and the conservation of endemic species. Sacred groves and natural habitats are prioritized for preservation. Waste Management sustainable solid waste and sewage management systems are proposed to prevent pollution of rivers and soil.

- **Disaster Risk Management**

Earthquake Mitigation given the region's seismic activity, construction regulations are proposed to ensure earthquake-resistant buildings and infrastructure. Flood Control mapping of flood-prone areas and the construction of drainage systems aim to mitigate flood risks. The preservation of wetlands and water bodies is integral to managing excess rainfall. Landslide Prevention slope stabilization techniques, afforestation, and careful planning of road alignments are key measures to reduce landslide occurrences. Balancing development needs with ecological conservation and addressing the vulnerability of remote areas to disasters. The region's natural resources can be leveraged for eco-tourism and renewable energy, promoting sustainable livelihoods while preserving the environment.

6. Conclusion and Recommendations

The New Mahabaleshwar Hill Station Area Development Plan represents a holistic effort to balance ecological preservation with sustainable development in one of India's most sensitive and scenic regions. By integrating Geographic Information System (GIS) and Remote Sensing (RS) tools, demographic analyses, and participatory planning, the plan addresses critical challenges, including environmental degradation, inadequate infrastructure, and socio-economic disparities. It seeks to create a roadmap for inclusive growth, ensuring that development aligns with the region's unique ecological and cultural characteristics.

The study area emphasis on eco-sensitive zoning, sustainable tourism, renewable energy, and disaster risk reduction underscores its commitment to long-term sustainability. Proposed land-use changes and infrastructure upgrades are designed to enhance regional connectivity, improve quality of life, and stimulate economic diversification, particularly through agro-tourism and heritage conservation. By incorporating community participation and adhering to regulatory frameworks such as the MRTP Act, the plan ensures inclusivity and compliance with environmental standards.

Recommendations

- **Strengthen Eco-Conservation Efforts**
Implement stricter monitoring and enforcement of eco-sensitive zoning regulations to protect biodiversity and prevent deforestation. Encourage community-led conservation programs to foster local ownership of environmental protection.
- **Promote Sustainable Tourism**
Regulate tourist inflows through carrying capacity analyses to prevent over-tourism and resource depletion. Develop eco-tourism infrastructure, such as nature trails, ropeways, and eco-resorts, with minimal environmental impact.
- **Enhance Infrastructure and Connectivity**
Prioritize road widening, new transport modes, and renewable energy projects to improve accessibility while reducing carbon footprints. Invest in public transport networks and electric vehicle infrastructure to ensure equitable and eco-friendly mobility.
- **Support Local Economies**
Establish agro-processing centers and promote agro-tourism to provide sustainable livelihoods for local communities. Facilitate skill development programs to enable residents to participate in emerging sectors like tourism and renewable energy.
- **Strengthen Disaster Resilience**
Develop comprehensive disaster management frameworks, including early warning systems and resilient infrastructure. Conduct regular community awareness programs on disaster preparedness and mitigation.
- **Foster Transparent Governance**
Establish mechanisms for regular monitoring, evaluation, and public reporting on the plan's progress. Encourage stakeholder engagement to ensure that development aligns with community needs and aspirations.

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