Interdisciplinary Journal
Registration No. 3341/2010

Vol. No. 34, June/July 2025
ISSN No. 2277-4858
Impact Factor (*IIFS*) 8.125

# THE KONKAN GEOGRAPHER

## Interdisciplinary Peer Reviewed Refereed National Research Journal

Half-Yearly


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# Editorial Note

*Konkan Geographers' Association Sindhudurg (India) is happy to bring out our 34th Volume of Research Journal, which include papers related to Geospatial technology, Trasport geography, Environment and Management, Disaster and hazards, Population Geography, Irrigation and Social Geography. We have taken extreme care to avoid mistakes but it may have inadvertently crept it. Neither the Konkan Geographers' Association of India, nor the Authors are responsible for any damage, or loss of and kind in any manner there from. Hence it is suggested that the reader should cross check the data, facts, and information given in the research papers with the authentic sources of data.*

*All global problems developed and accelerated in last 30 years, like Global warming, depletion of Ozone, depletion of resources, loss of biodiversity, population explosion, pollution etc. were developed due to the developmental activities of man. All these things were beyond the tolerance capacity of our mother earth, our environment. Our mother earth, Environment or Nature has given us time for introspection about ourselves, our life and our economic activities, our development.*

*Global Challenges are many and are interrelated to each other. Though the root cause of most of these problems is man and at this critical stage it is impossible for man to rectify them totally.*

*At least we can concentrate on the problems for which we can find solutions to reduce intensity of these problems and will help in sustainable development of different parts of the world. Global Challenges are many and are interrelated to each other. Though the root cause of most of these problems is man and at this critical stage it is impossible for man to rectify them totally.*

*e are thankful to Dr. Paromita Majumdar (West Bengal), Dixita Shinde (Goa), Dr. Uttam Gadhe (Raigad), Mr. Santosh Ghadi (Goa)*

*We also thank all the Research Scholars for their contribution in this volume.*

*"Success comes to those who dare and act"*

**Co-Editor**
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Journal Volume No. 34 (June/July 2025)
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(National Interdisciplinary Peer Reviewed Refereed Research Journal)
KONKAN GEOGRAPHERS' ASSOCIATION SINDHUDURG (INIDA)

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# Unveiling the Resilience of an Arambol Village through a Freshwater Storage Dam

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**Research Paper Received on 12-06-2025 Edited & Accepted on 27-07-2025**

**Abstract :**

*The concept of water sustainability involves ensuring a sufficient and clean water supply for present and future generations. This coastal village benefits from plentiful access to water. Arambol is a small village located at a distance of 24.6 km from north of Goa's Capital city, Panaji. It is a traditional fisherfolk village and a tourism hotspot. This paper represents one such case study of the Arambol Dam, which is a small water Storage structure surrounded by forest, sacred groves, and fresh water streams. The paper aims to identify the underlying reasons for the water scarcity in the village and to examine the long-term viability of using groundwater. With the dam's diminishing effectiveness, the village has increasingly turned to groundwater, resulting in residents having to wait for their daily water supply. Data sources include primary data collection in the field, i.e., interviews and surveys and secondary data such as Google Earth imagery for mapping. Methodology consists of this study, use of GPS checkpoints, interviews and a lowdown primary survey is being done. Hence, it has been concluded that the precious water can be saved in an economic way so that our future generations don't face the curse of water scarcity.*

**Keywords :** Water Sustainability, Water scarcity, Bore well, Ground water, Sacred grooves.

## Introduction:

Goa, known as the "Rome of the East," is part of the Konkan region with a 103 km coastline and rich history, from early tribes to Portuguese rule. It lies on the western coast of India and comprises 12 talukas. Major rivers include Mandovi and Zuari, along with others like Chapora, Sal, and Talpona.

Water scarcity in Goa worsens during the dry season due to low rainfall, overuse of groundwater, pollution, and inadequate storage infrastructure. This study highlights water scarcity in Arambol village, where declining dam effectiveness has forced greater reliance on borewell groundwater, causing delays in daily water supply.

## Objectives:

1. To study the impact of the freshwater Storage Dam in Arambol village.
2. To identify the households facing scarcity of fresh water in Arambol village.

## Data Source:

This study is based on both primary and secondary data. The primary data is basically the observations done by the researchers themselves, through field visits and interviewing the local residents. A random sampling technique has been employed to collect the data. In addition, 30 households have been surveyed with the help of a structured questionnaire. Moreover, secondary data is collected from the research articles, project works, village panchayat Arambol and the census of India as well as websites.

## Methodology:

The study used both numerical and descriptive methods to analyse Focus Group Discussion data. Numbers showed how common each opinion was, while transcripts were studied to identify key themes, repeated ideas, differing views, and points of agreement. Word-for-word quotes, patterns, and visuals like

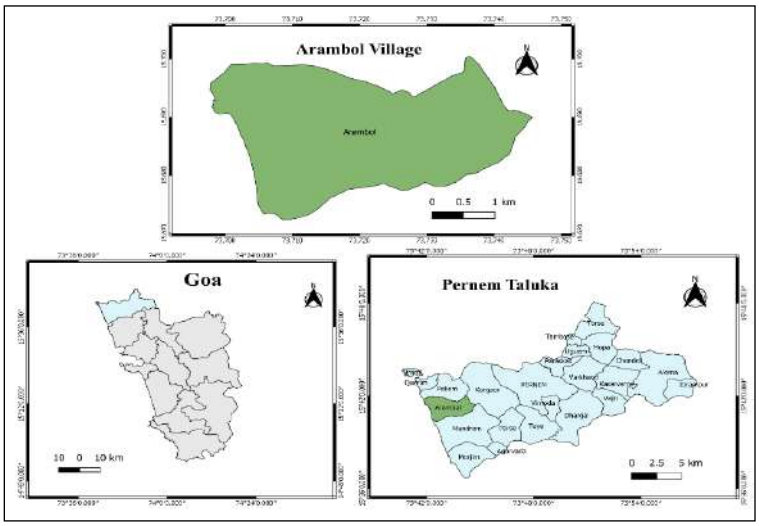
graphs and pie charts helped present a clear picture of the group's views. This approach gave a detailed understanding of the discussion's dynamics.

**Study Area:**

Arambol village (15.6871° N, 73.7213° E) is located in Pernem Taluka, Goa, about 24.6 km north of Panaji. It is a small coastal village with a population of around 5,300 (Census 2011) and is divided into six wards. Known for its fishing traditions, Arambol is also a popular tourist destination and a hub for yoga, meditation, and alternative therapies.


**Source: Google Earth Pro, Prepared by Author, 2024**

The village has a 2.5 km coastline and attractions like Sweet Lake and the Arambol Dam, built for irrigation. Religious sites include major temples such as Ravalnath, Bhumika, and Narayan Temples, along with smaller shrines. Prominent churches include Mount Carmel Church, and chapels like Holy Cross and St. Anthony Chapel.




**Source: Survey of India, Prepared by Author, 2024**

**Arambol Dam:**

Dams are said to be an important source of water supply and of high importance for various other reasons. They supply water for various means, including domestic use, irrigation, etc. In Harmal (Arambol) village, there is such a dam, which is considered a religious place. The Arambol Dam is located at the latitude of 15°41'48.87"N and the longitude of 73°42'51.36"E. The Arambol dam is surrounded by the scenic beauty of trees. The place surrounding the dam is sacred place. It is said that the sacrifice of 150 roosters is done by the people to the God Shri Sheneshwar Prassan. The main devotees are Korkhankar, Bankar, and Mandrekar. During the sacrifice of animals in the evening time chicken curry is prepared (Vadval) many people take part in this ritual. This sacrifice is done every year in the month of June or July. This place is meant to be kept clean as it is a sacred place. Women are not allowed to visit this place.

People of this village use the water of the dam for irrigation purposes. E.g., coconut tree plantation, chilli, etc. The dam is also famous for tourism activities, people from different parts of Goa and many foreigners visit this place for leisure.

**Historical Significance:**

The Arambol dam holds historical significance as a key infrastructure project aimed at improving agricultural productivity and water management in Goa. According to the villagers, the dam was constructed in the year 1966. The dam also holds religious significance as the place has the temple of God Shree Sheneshwar, the protector of the place and it is believed that the water of the stream has medicinal properties. It is worshipped as holy water.

Based on the focus group discussion, it has been determined by the researchers that the construction of the dam represented a significant milestone for the villagers. This is because it provided them with a reliable source of irrigation water for agricultural use, as well as meeting their daily needs for drinking, cooking, washing, and bathing. Additionally, the flowing water from the dam was utilized by the farmers for cleaning their tools and animals.

**Impact of Arambol Dam on rural development:**

The Arambol Dam has had both positive and negative effects on the environment and local communities. Its main impact is on agriculture, providing reliable irrigation that boosts crop production and improves farmers' livelihoods. It also supplies drinking water and helps control floods during the monsoon. Besides its practical uses, the dam's natural beauty attracts visitors, offering potential for eco-tourism. Overall, the dam supports agricultural sustainability and contributes to the area's rural economic growth.

**Present Condition of the Arambol Dam: A Comprehensive Overview:**

The Arambol Dam still serves its purpose but faces several challenges. Irregular maintenance has led to wear and tear, minor leaks, and erosion, raising concerns about its structural safety. Sedimentation has reduced storage capacity, and changing rainfall patterns due to climate change affect water availability.

Currently, dam water is only used during the annual 'Vadval' ritual. The stream feeding the dam has weakened, causing it to dry up in summer and fill during the monsoon. Despite these issues, the dam attracts locals and tourists for swimming, photography, and recreation.

**Demographic Characteristics of Korkhankar Wada, Arambol:**

Researchers collected demographic data from 21 respondents in Korkhankar Wada, Arambol, to support the study with deeper insights. Respondents ranged from early twenties to fifties, showing a mix of life stages without major age clustering. Most participants were male, which may reflect broader trends or sample characteristics, potentially influencing survey findings.

Occupations were diverse, with many in the service sector, followed by business professionals, job holders, students, and a few teachers, accountants, and housewives. This shows a varied socio-economic background. Most families had 4–5 members, indicating a preference for moderately sized families.

All respondents had lived in Arambol for over 20 years, showing strong community roots and a deep connection to the village.

**Awareness of the freshwater storage dam project in Korkhankar wada, Arambol:**

The results of the survey indicate a high level of awareness among the community regarding the dam project. Almost all participants indicated they were aware of the project, suggesting that the information has been successfully disseminated throughout the village. This widespread awareness reflects effective communication strategies and a well-informed population.

**Initial sources of information about the freshwater storage dam project"**

The initial awareness of the Arambol freshwater dam among village residents predominantly came from within the community itself. Most individuals learned about the project through conversations with local villagers in their immediate surroundings. This grassroots method of information dissemination highlights the close-knit nature of the community, where news and important updates are shared through word of mouth.

**Initial perception of the freshwater storage dam project:**

The survey results reveal that the initial perception of the freshwater storage dam project in Arambol village is overwhelmingly positive among the respondents. The vast majority of villagers view the project favourably, reflecting their support and optimism about the benefits it may bring to the community. This strong

positive sentiment indicates that many residents likely recognize the potential for improved water resources and the advantages such a project could offer.

**Experience of water shortages in Arambol village before the dam project:**

The survey responses to the question about experiencing water shortages in Arambol village prior to the dam project reveal that most residents did not face such issues. The vast majority of respondents reported that they had not encountered water scarcity before the dam's construction. This suggests that water availability was generally sufficient for the needs of the community before the project.

**Primary sources of water before the dam project:**

Before the dam project, most villagers relied on rivers as their main water source, showing the importance of natural waterways. A smaller number used wells, while many also mentioned 'Whaal', small water streams, highlighting the community's use of diverse water sources.

**Current Primary Water Sources:**

Since the dam's construction, most residents now rely on wells, showing increased dependence on groundwater. Tap water usage has risen, indicating better infrastructure. However, many still depend on water tankers, showing the need for supplementary supply.

**Frequency of Water Problems:**

Many respondents face water issues several times a week, especially during summer. Some experience problems occasionally, while one reported no issues at all.

**Perceived Improvement in Water Availability:**

Most respondents believe water availability has improved since the dam was built, showing its effectiveness. However, a few did not notice any change, pointing to varied experiences.

**Impact on Agriculture:**

There is strong agreement that the dam has benefited local agriculture by improving irrigation and water access. No one reported a negative impact.

**Social and Economic Benefits:**

The majority observed social and economic improvements after the dam's construction, such as better livelihoods and local development. A few did not notice any changes.

**Long-Term Resilience:**

Most respondents feel the dam has strengthened Arambol's ability to deal with water scarcity and environmental challenges. Some were neutral, suggesting mixed or uncertain views.

**Suggestions for Future Measures:**

Most residents see dam reconstruction as key to solving water issues. Others suggest additional infrastructure projects or broader strategies to boost water resilience in the village.

**Limitations:**

1. During the survey, we encountered a limitation in the form of the small size of the ward, which consists of only 21 houses. This made it challenging for us to conduct a quantitative analysis.
2. The process of marking the waypoints for digital mapping posed another challenge due to the presence of almost 16 bore wells within a 1 km radius. According to regulations, these bore wells should not be located in close proximity to each other. It was observed that the public was reluctant to grant permission for the inspection of these bore wells.

**Recommendations:**

- The study identified key findings on Arambol village, its freshwater dam, historical importance, and social-environmental impact.
- Future research should focus on dam reconstruction using historical insights and advanced materials for better durability.
- Adoption of modern technologies is needed to improve dam monitoring, maintenance, and efficiency.
- Strict rules must be implemented to protect dam sites, ensuring environmental safety and structural stability.

- A combined approach will help improve dam management and promote safer, sustainable practices in the region.

**Conclusion:**

The freshwater dam in Arambol village is a key example of community resilience and sustainable water use. Traditionally important for irrigation and religious reasons, the dam now faces reduced effectiveness, leading to water scarcity and increased dependence on groundwater. Daily water supply has become unpredictable, stressing the need for better water management.

Using both field surveys and mapping, the study highlights the urgency of preserving existing water sources and identifies households most affected by shortages. While the dam remains beneficial, its future depends on regular monitoring and maintenance.

The study recommends investing in water infrastructure and involving the community in managing resources. By combining local knowledge with modern solutions, Arambol can better handle future water challenges and ensure clean water for future generations.

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THE KONKAN GEOGRAPHER
Vol. No. 34, June/July 2025, ISSN No. 2277-4858
Impact Factor *(IIFS)* 8.125
(Interdisciplinary Peer Review Refereed Research Journal)

# Sustainable Resource Management in the Stakmo Watershed of Leh Valley with Geospatial Analysis

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**Research Paper Received on 12-06-2025 Edited & Accepted on 27-07-2025**

**Abstract:**

*In order to sustainable utilize of natural resources and maintain ecological balance in high altitude cold desert area, small watershed management should be more emphasised. The Leh valley is mainly drained by the river Indus. Beside the main river Indus, in Leh valley there are so many small tributaries flowing from the north-eastern Ladakh Batholith Ridge. Those streams are locally termed as Lungpa.The small streams are mainly fed with glaciers and snowmelt water. The important streams are; Taru, Phyang, Khardung , Sabu , Stakmo , Nang etc. Those small streams contribute remarkable amount of water and sediments into the Indus river.Apart from this, those small streams have great influence on the development of periglacial landforms, and land use patterns along their valleys.A number of villages and settlement areas have been developed in the small watersheds depending on snowmelt water, soil and natural vegetation resources. The present work is an effort to illustrate the sustainable resource management in Stakmo watershed in leh valley with geospatial analysis*

*The study also seeks to emphasis the necessity of the small watershed management to sustain the natural resources (snow melt water, natural vegetation etc.) for the existence of the villages and settlements in in high altitude cold desert area.*

**Keywords:** Sustainable resource management, Stakmo watershed; environmental hazard.

## Introduction:

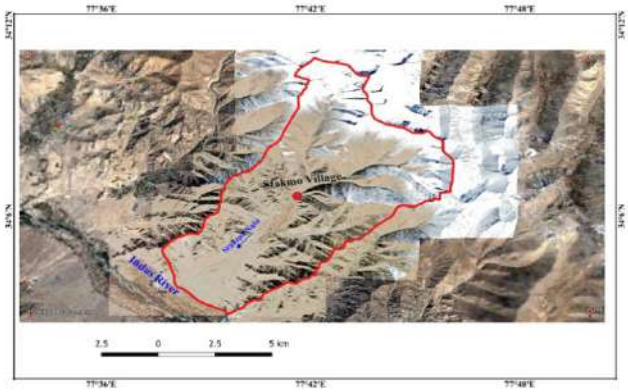
Small watershed management is crucial for sustainable resource management and ecological balance, especially in mountain areas. It includes the integrated management of land and water resources within a specific geographic area. In order to conserve soil, water, grasslands, natural vegetation resources of a vast areas, planners should emphasis first on small watershed resource management. This kind of small approach will holistically improve agricultural yields as well as community livelihoods. The present paper is concerned with sustainable resource management in Stakmo watershed in leh valley with geospatial analysis. Indus is the main river of the Leh Valley. The river has great influence in development of land forms and landuse pattern under periglacial environment situated in high altitude cold desert area. Most of the part of Ladakh area is under barren land due to lack of water and soil resources. Hence, existence of lives in this hard climatic region is very difficult. That is why development of settlement area in Ladakh area is mainly restricted in valleys where snow melt streams are present.The Stakmo river is one of the important tributaries of the Indus. Beside the main river Indus, in Leh valley there are many perennial streams such; Taru, Phyang , Khardung , Sabu, Stakmo, Nang etc. flowing from the north-eastern Ladakh Batholith Ridge. The streams are locally termed as Lungpa. Those streams are mainly fed with glaciers and snowmelt water. The rain shadow Ladakh area has been several times highlighted in many studies for its cloud burst induced flash flood vulnerability previously in different years specially in Leh valley (Zieglat et al., 2016). A number of scientists (Barrett, 2014) has focused their studies on climate change and associated glacial retreat problems in the area. Searle (2011) had benchmark contribution in the study of geology in Ladakh and Karakoram ranges. Many scientists (Sant et.al.,2011) have also emphasised on geomorphological classification of Leh valley emphasising on periglacial landforms. They identified the north-eastern part of the

Leh valley (mainly the foothill parts of the Ladakh Range) as amphitheatre valley. Koul et. al 2016 published report on the volumetric changes of glaciers in Drass glacial basin over the past 50 years (1962-2013) based on remotely-sensed data. Gupta and Arora (2017) elaborated vividly the characteristics of the soils of Ladakh region of Jammu and Kashmir. Undoubtedly, nature of soil has great influence on agricultural production as well as land use pattern. Sangode et al.,(2017) have analysed the sedimentary and geomorphic signatures of 2010 cloudburst triggered flash flood in Leh valley. Mujtaba et.al 2017 identified the geomorphic imprints of the paleolakes, alluvial fans and other landforms around Leh. Many renowned scientists (Bisht. etal.,2008, Raghuvanshi et.al.2019) have contributed their valuable research works on agricultural land use patterns and associated problems in Leh and its adjoining areas. Dame et al., 2019 nicely elaborated the scenario of rapid urbanisation of the Leh town as well as the conversion of the barren land and agricultural land into built up area. However, the earlier scientists have hardly focused on the importance of small watershed management towards conservation of the water and soil resources to sustain the villages and settlement areas.

Hence, the present work is an effort to illustrate the importance of the Stakmo watershed management to sustain the natural resources (snow melt water, soil and natural vegetation etc.) for the existence of the villages with the help of geo-spatial techniques.

**Materials and Methods:**

The paper is prepared on several secondary data and primary data including field observation. The secondary data includes satellite images (google earth, 2022), valuable literatures and the primary data consists of local people perception and field recorded data with photographic evidences. Based on several previous literature review specific research gap regarding Stakmo watershed management. Field verification was done to gather different types of primary data of the Stakmo watershed (landform study, nala morphology analysis, observation of land use practices etc.), photographic evidences including the people perception about the flashflood in Stakmo village and adjacent area.Analysis of the secondary data regarding physical setup (physiography, climate, geology)was so important to explain the causes the natural environmental hazards in Leh valley and Stakmo watershed .Morphometric interpretation of the watershed has been done based on SRTM DEM. Study of different hazard and disaster related secondary data (incidences of different hazards and casualties) has been emphasised in this paper for better understanding the magnitude and severity of those hazards. Field based observation of land use pattern along the Stakmo dry fan was also very relevant for better understanding about the land use pattern of the area. Depending upon the analysis of the collected primary and secondary data special emphasis has been given on the importance of the Stakmo watershed management towards the sustainable utilization of natural resources. Few effective measures have been discussed towards the sustainability of the natural resources for the betterment of the Stakmo villagers.




**Results -**

**Geospatial attributes of the Stakmo watershed**

The Stakmo basin (fig:1) is extended from 34°0' north to 34°12' north and 77° 30' east to 77° 47'east . The area of the Stakmo watershed is about 85.6 sq. km. The maximum length of the basin is 14.2 km. Perimeter of the basin is 48.1 km. The length of the stream is about 15.6 km. The basin is less elongated

(elongation ratio 0.73). The form factor of the basin is 0.42.The present investigator have surveyed the watershed in 2014 for ground truth verification. The Stakmo valley is situated towards the north- east direction of the Shey fort as well as the famous Druk Padma Karpo school. The Stakmo valley (elevation about 3800 m.) is situated 26 km far from Leh city. It is believed that the name of the village is derived from the village's shape which resembles as a Tiger or 'Stak' in Ladakhi language. According to the studies of several scientists (Sant et al., 2011) the Stakmo valley actually falls under amphitheatre valleys. The table.1 shows different parameters of the small Stakmo watershed.

**Table 1. Stakmo watershed parameter**

| Parameter | Area |
|---|---|
| Watershed area | 85.6 sq.km |
| Maximum length | 14.2 km. |
| Maximum width | 6.55km |
| Perimeter | 48.1 km. |
| Length of the Stakmo nala | 15.6 km. |
| Form factor | 0.42 |
| Elongation Ratio | 0.73 (less elongated) |

*Source: computed by the authors*

The stream is mainly snowfed originated from the Ladakh range .It is 4th order stream (fig no.2). The stream has developed an elongated dry fan which has been shown in the basin map (fig no.3). About fifty 1st order channels have been found in the watershed. The number of the 2nd order channels are eight. Three channels have been observed as 3rd order. The table 2 shows number of streams and bifurcation ratio of different order. Bifurcation ratio ($R_b$) has been calculated by the author to assess the structural control on drainage (table:2).Depending on the field verification the author has identified varied micro landforms and land use features in the watershed. Prominent breaks in longitudinal profile of the stream have been observed from the field survey.A prominent gorge of more than 6 metres depth was noticed along the Stakmo upstream, which is very significant evidences regarding active fluvial erosion as well as the supply of sediments from the sediment producing zone of the watershed.

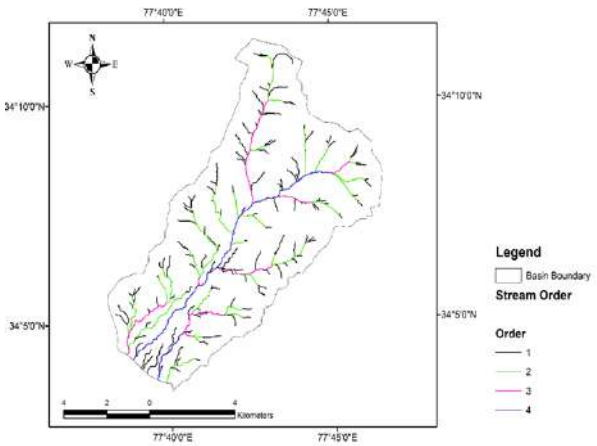



**Figure 2.** Stream ordering map of the Stakmo watershed after Strahler (Source: SRTM, DEM)

**Table 2. Number of streams and bifurcation ratio in Stakmo watershed**.

| Stream Order | Number of Streams | Bifurcation Ratio |
|---|---|---|
| 1st | 50 | - |
| 2nd | 8 | 6.25 |
| 3rd | 3 | 2.67 |
| 4th | 1 | 3 |

**Geotectonics and lithology:**

The watershed is a desert of bare crags and granite dust with mostly rocks of sandstones, shales and conglomerates. The crystalline rocks-gneisses and schists occupy large areas of the watershed. Because of physical weathering of rocks in the cold desert, large quantity of detrital material is seen in the valleys and dry uplands, forming a peculiar kind of mantle rock or regolith which consists mostly of fresh un-weathered rock material (Gupta and Arora, 2017). This large quantity of detrital materials of the upland areas plays as important source of sediment in various channels .Apart from these, the combination of un-weathered rock materials, debris with excessive rainwater flow (during flash flood) resulted devastative impacts over existing land use pattern of the Stakmo watershed. Lal et al., (2019) has emphasised the tectonic influence on the landform development in Ladakh region. According to their studies there are different types of depositional landforms like; terraces, fans, lake-deposits and moraines which contain records of several climatic fluctuations during the Quaternary period and there are three major factors which have primarily influenced the geomorphic evolution of the study area which include the geology, the tectonic activity and the climate. The development of entire Leh valley is greatly influenced by the episode of the Indian and Asian plate movements. Tectonically, the area is very dynamic, which is reflected from the alignment of the river Indus and its different channel forms characterised with incised single channel, great variability of the channel width, wide braided course . Searleet al., (2011) already stated that the continuous northward movement of Indian plate forcefully deformed the molasse, where several north verging thrusts and folds are formed. These faults probably are active during late Quaternary to recent. Those faults and thrusts have profound influences on the alignment of different tributaries of the river Indus.

**Geomorphology of the Stakmo watershed:**

Stakmo is a tributary of the Indus river flows along the contact zone of the Ladakh Batholith and Indus meta sedimentaries in a 0.5–2 km wide meandering valley around Leh. Many scientists (Sant et.al.,2011) have identified amphitheatre valleys characterised with triangular funnel shaped deglaciated valley bounded by steep rocky slopes on three sides within Ladakh hill range comprising glacial out wash and lag deposits all along the valley floor. At the upper part of the Stakmo stream a prominent amphitheatre valley has been observed by the author. The Stakmo amphitheatre valley is characterised with steep rocky slopes on three sides with lag deposits all along the valley floor. After the amphitheatre valley the stream has developed a fan topography over which Stakmo village has been developed. The dry periglacial fan is characterized with steep slope and heterogeneous size of sediments.Prominent terminal moraines are observed over the floor of the amphitheatre valley. The moraines are heavily weathered under the influence of periglacial environment. For better understanding the terrain characteristics of the watershed, morphometric analysis has been done.

**Morphometric analysis of the Stakmo watershed:**

A relative relief map(fig:3) of the watershrd has been prepared based on SRTM DEM. The apex of the Stakmo fan (fan apex ,34° 7' N & 77° 42' 1" E) is shown in the map. Above the apex of the fan prominent

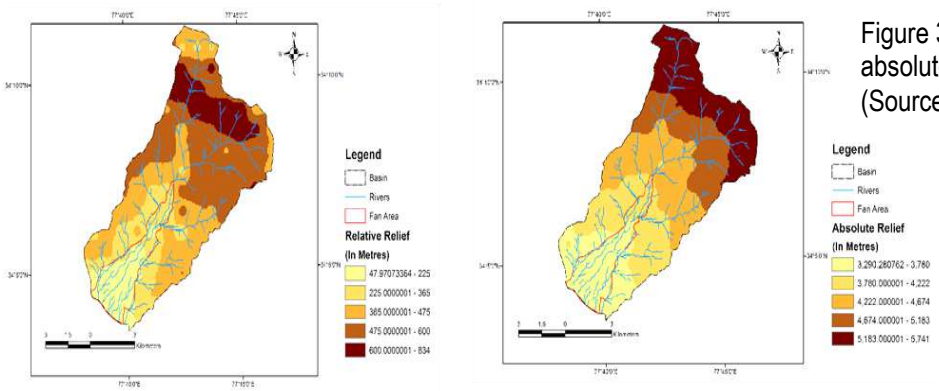



Figure 3: Relative relief and absolute relief.
(Source: SRTM, DEM)

amphitheater valley is located. Excessive terminal moraines are observed over the floor of the amphitheatre valley. The moraines are heavily weathered under the influence of periglacial environment. Heaps of weathered moraines are the source of sediment of the Stakmo fan . According to the villagers during 2010 cloudburst induced flash flood debris flow from the upper course of the basin or from amphitheatre valley caused devastation in downstream settlement area over the Stakmo fan and the campus of the Druk a Lotus school.

Maximum relative relief is (834 m - 600m) seen at the upper part of the basin. The vast lower fan shows the relative relief from 225 m-47m (fig no-3). Maximum slope ( 41°-69°) is observed in the upper part of the watershed where mass wasting process is very active. Over the fan surface the average slope is 1° – 12 ° where the Stakmo village is located. The Stakmo stream is flowing over this fan area with its salientc channel forms. The absolute relief map (fig no-3) of the watershed clearly indicates fan surface with gradual decline of the elevation. The elevation of the upper fan varies from 3780m – 4222m.On the other hand, elevation of lower fan varies from 3290m.-3780m.

**Natural hazard in the Stakmo watershed:**

The Stakmo stream provides the water to the whole Stakmo village. More than fifty families live in the village. The villagers face environmental problemslike; excessive snowfall, flashflood induced debris flow, soil erosion, earthquake etc. There is a large stretch of barren land. The present researcher has evidently observed the geomorphic signature of the 2010 flash flood along the Stakmo valley in its upper reaches where the cloud burst induced flash flood resulted into significant vertical and lateral cutting increasing the channel widths along with a sharp axial incision of Stakmo bed . The feeder channel has actively eroded its bank in the form of toe erosion. The feeder channel is filled with granitic gravels in heterogeneric sizes that observed by the author during field survey. Based on field observation it was clearly understood that 2010 flash flood events had brought excessive gravels and boulders in the channel of Stakmo. According to the local source, at the upper reach of the dry fan, mainly extensive part of the left bank was totally washed away in form of debris flow by the devastating 2010 flash flood. Distinct altitudinal variation in between the both sides fan surface of the river clearly indicates that. According to the Stakmo villagers the debris flow originated from the upper part of the amphitheater valley during flash flood 2010.

**Table 3:** Maximum and minimum temperature (°c ) at Leh

| Month | Year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2010 | | 2012 | | 2013 | | 2014 | | 2015 | | 2016 | |
| | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min |
| Jan | 0.13 | -15.39 | 0.1 | -15.4 | 3.0 | -10.54 | -0.03 | -13.53 | 0.8 | -13 | 1.3 | -13.4 |
| Feb | 0.59 | -10.32 | 0.6 | -10.7 | 1.67 | -10.23 | 0.75 | -9.88 | 3.3 | -8.5 | 4.3 | -10.2 |
| March | 8.9 | -2.26 | 9.2 | -2.3 | 8.48 | -4.85 | 7.08 | -5.15 | 7.0 | -4.9 | 9.7 | -5.1 |
| April | 12.62 | 1.53 | 12.7 | 1.5 | 12.6 | -0.25 | 12.3 | -0.48 | 12.5 | -0.2 | 12.9 | 0.8 |
| May | 15.58 | 4.6 | 15.53 | 2.67 | 16.3 | 3.79 | 16.96 | 3.35 | 16.7 | 4.1 | 19.3 | 4.9 |
| June | 17.36 | 6.1 | 18.6 | 7.53 | 23.4 | 9.5 | 20.69 | 9.25 | 19.5 | 7.6 | 24.2 | 11.5 |
| July | 24.23 | 12.63 | 26.59 | 13.87 | 26.85 | 13.58 | 26.17 | 13.37 | 25 | 11.5 | 26.1 | 14 |
| August | 25.08 | 12.55 | 26 | 13.29 | 26.11 | 12.66 | 24.54 | 12.03 | 25.1 | 12.3 | 24.8 | 13.4 |
| September | 20.01 | 7.8 | 20.51 | 7.6 | 21.25 | 7.0 | 18.76 | 6.65 | 18.9 | 6.0 | 22.1 | 7.7 |
| October | 14.5 | -1.85 | 11.77 | -1.74 | 15.66 | -0.03 | 14.59 | -0.01 | 15 | 0.2 | 15 | -0.3 |
| November | 9.5 | -7.92 | 7.72 | -5.05 | 13.8 | -8.33 | 8.41 | -8.08 | 9.1 | -5.2 | 9.5 | -6.3 |
| December | 3.23 | -12.97 | 1.56 | -12.5 | 2.95 | -12.41 | 291 | -11.69 | 2.2 | -10.8 | 5.9 | -11.6 |

Source: Statistical Handbook, Leh, 2016

**Cloudburst induced flash flood*:***

Though cloudburst in Ladakh is unnatural because it is a rain shadow area. In spite of this, according to data provided by the India Meteorological Department Leh experienced cloudburst events earlier. During the month of August (2010) Leh received abnormally very high amount of rainfall (58.4 mm)(table:4)that caused devastating flash flood resulting massive losses of lives and properties. The people of Stakmo watershed had also experienced very adverse impacts of that flash flood event .

**Landuse pattern in Stakmo watershed :**

Based on physical environmental characteristics, interesting landuse pattern has been developed in the study area. Major land uses pattern of the study area (fig. 5) are settlement, roads, agricultural lands, water bodies, canal, gazing land etc. Most of the part of the watershed is stoney waste lands.At the southern part of the area Stakmo stream induced deposition is prominently observed. Northern part of the watershed vast snow covered area is observed. Most of the areas (39.88 sq. km.) of the basin is under stoney waste.The extended stoney waste land is covered with lag stone and deep weathered rocks. The upper part of the Stakmo watershed is mainly snow covered area (33.67 sq.km.), which plays significant role to supply water into the Stakmo river. Only 6.23 sq. km. (Table: 5) area is under agricultural land. Mainly the lower and middle portion of the basin settlement area and agricultural lands are found. Only 1.2 sq. km. area is under river and water bodies.The village Stakmo which falls under Leh block is situated on the western part of the Stakmo river and extended from north-east to south-west along the Stakmo fan . There is no doubt that the village area has been developed depending on soil and water resources of the Stakmo fan. Plantation of willow trees are seen in different parts of the village. There is an extended part of barren land covered with lag stone and deep weathered rocks mainly in the upper part of the dryfanarea. Organised irrigation network of earthen channels (called 'yuras') are constructed to properly distribute Stakmo stram water into agricultural fields. Prominent agro-based livelihood of the

**Table 4:** Amount of Rainfall and snowfall in Leh and adjacent area

| Month | Year | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2009 | 2010 | 2012 | 2013 | 2014 | 2015 | 2016 |
| Jan | 6.6 cm (S) | 1.5 cm (S) | 1.5 cm (S) | 3.9 cm (S) | 6.0 cm (S) | 0.5 cm (S) | 1.8 cm (Snow) |
| Feb | 2cm (S) | 7 cm (S) | 7.0 cm (S) | 4.6 cm (S) | 0.4 cm (S) | 0.6 cm (S) | 1.8 cm (Snow) |
| March | 0.5 cm (S) | 1.1 cm (S) | 1.0 cm (S) | - | - | 3.6 cm (S) | NIL |
| April | NIL | 8.8 cm (S) 41.1 mml | 1.0 cm (S) | 10.0 mml | - | 8.5 mm (R) | 4.6 mm (rain) |
| May | NIL | 6.7 cm (S) 19.6 mml | NIL | - | - | 0.2 mm (R) | NIL |
| June | 4.4 mml | 35.5 mm (R) | 19.6 mm (rainfall) | 15.7 mm (R) | - | 11.2 mm (R) | NIL |
| July | 3 mml | 2.5 mml | 1.9 mm (rainfall) | 22.0 mm (R) | 29 mm (R) | 6.8 mm (R) | NIL |
| August | 5.5 mml | **58.4 mm (R)** | 9.1 mm (rainfall) | 24.2 mm (R) | 2.6 mm (R) | 57.4 mm (R) | 8.4 mm (rain) |
| September | 10 mml | 12.5 mm (R) | 1 mm (rainfall) | 2.9 mm (R) | 45.4 mm (R) | 23.4 mm (R) | NIL |
| October | 4 mml | 0.9 cm (S) | NIL | 7.6 mm (R) | - | 0.6 mm (R) | NIL |
| November | 19 cm (S) | NIL | NIL | - | - | NIL | NIL |
| December | 3 cm (S) | 9.7 CM (S) | NIL | 0.4 cm (S) | 1.8 cm (S) | 0.9 cm (S) | NIL |

Source: Statistical Handbook, Leh, 2016, R-rainfall,S-snowfall.

Table 5. Land use land cover area of Stakmo watershed

| Major land use and land cover | Area in Sq. Km. |
|---|---|
| Agricultural land | 6.23 |
| Settlement | 2.1 |
| River and waterbodies | 1.2 |
| Snow covered area | 33.67 |
| Stoney waste | 39.88 |
| Stakmo nala deposits | 3.99 |

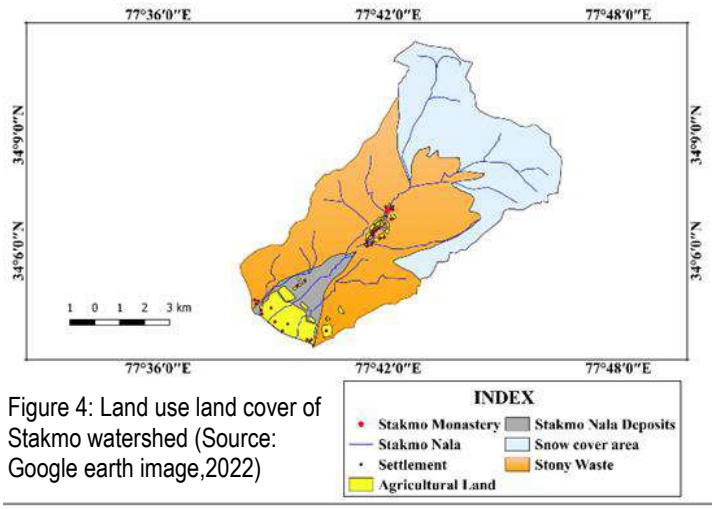



Figure 4: Land use land cover of Stakmo watershed (Source: Google earth image,2022)

villagers has been observed during field survey in September, 2014 by the authors. Apart from agriculture they depend on animal husbandry.

The major socio-economic problems faced by the dwellers of the village are related with transport, unemployment, sanitation, drinking water, medical and other services. Beside the socio-economic problems, there are some natural hazards like cloudburst induced flashflood, earthquake, excessive soil erosion etc. that also damage the lives and properties of the villagers.

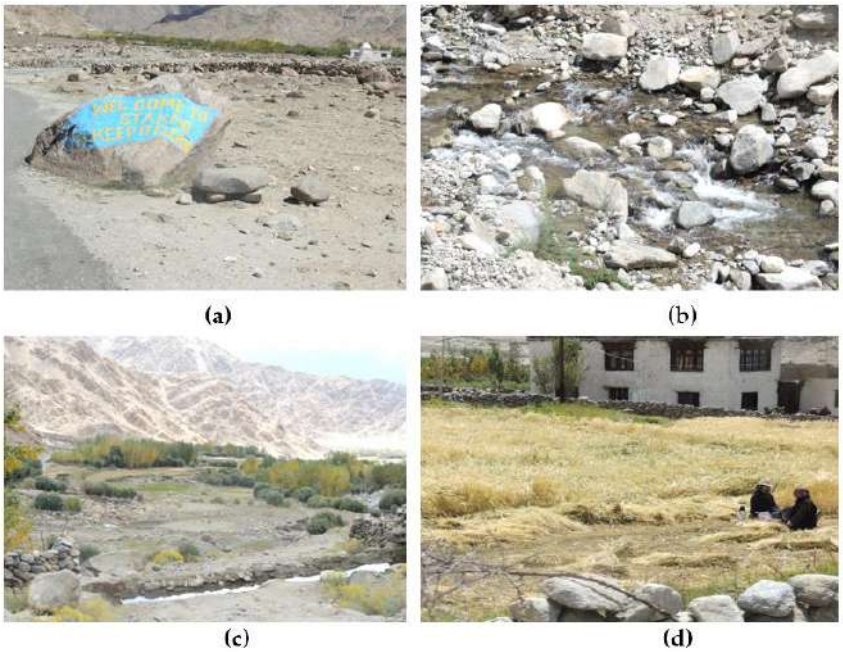



**Figure 5.** (a) Way to the Stakmo village. (b) Water flow in Stakmo nala. (c) Irrigation canal for diversion of Stakmo river water. (d) Stakmo villagers busy in agricultural field.

Source: field survey,2014.

**Discussion :**

The Stakmo watershed is located in the higher altitudinal cold desert environment. Important topographic features of the Stakmo basin like amphitheatre valley, dry alluvial fan surface, Stakmo lower floodplain have positive role for development of the settlement of the Stakmo village . Construction of houses and roads should be confined in relatively safer zones of the watershed, where possibility of hazards like ; landslides, flash floods are comparatively lesser. In this context scientific land use planning should be guided by proper hazard zonation maps.

Glaciers and snow of the watershed have crucial contribution in supply of water resource to the Stakmo stream. As the area is located in rain shadow zone, hence source of irrigated water and types of crop cultivation entirely depends on snow and glacier meltwater. Hence scientific harvesting of snowmelt water would be emphasised.

Apart from the Stakmo river, there are many other streams (Taru ,Phyang , Khardung , Sabu , Stakmo, Nang etc. ) in Leh valley, that play significant role to develop elongated and slopy dry fans over which many settlement areas have been developed depending on its water and sediment resources. So the local authority has crucial role for giving more emphasis on those small stream watershed management for sustaining many villages situated over the watersheds.

Local villagers depend on agriculture and horticulture. The economy of the area is mainly based on farming (highland barley, wheat, potatoes, apricots are the traditional crops) and animal husbandry (donkey, yak, cow). Presently, with the sharp increase of agriculture as well as horticulture, day by day water scarcity for agriculture is becoming more acute. Leh receives scanty rainfall and fed by numerous channels that stream down glaciers in this region. Stream water plays an important role in irrigation activities. However,

efforts are being made to bring more barren land under cultivation by constructing irrigation canals on the Indus, Shayok and other tributaries (Raghuvanshi et al., 2019).

**Conclusions :**

Along the Leh valley there are a number of important small streams which have key role to supply necessary natural resources (snowmelt and rain water, sediments) to develop a number of important villages, tourist places and settlement areas with agricultural lands, grazing lands etc. Apart from morphometric analysis, field based observation regarding landuse and land cover characteristics of the Stakmo watershed including perception study of the local people have been tried to discuss above. Based on the comprehensive study it can be concluded that Stakmo watershed management is very necessary towards conservation, regeneration and sustainable utilization of land and water resources. Successful implementation of a number of watershed development projects on several small watersheds can holistically improve agricultural yield as well as the sustainable development of land, water, vegetation resources in the entire Leh valley.

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THE KONKAN GEOGRAPHER
Vol. No. 34, June/July 2025, ISSN No. 2277-4858
Impact Factor *(IIFS)* 8.125
(Interdisciplinary Peer Review Refereed Research Journal)

# Land Use Transformation and Its Impact on Vegetation Cover in Panshet Catchment

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**Research Paper Received on 12-06-2025 Edited & Accepted on 28-07-2025**

**Abstract:**

*Catchments located in the western Maharashtra are witnessing dynamic land use changes since many years. These vicious changes are triggering continuous depletion of soil, water, and vegetation cover. Major modifications in physical environment due to natural and human induced activities now can be assessed and mapped accurately. Today land cover mapping is one of the most common and imperative applications of remote sensing and Geographical Information System (GIS) technology. High resolution satellite data has facilitated spatio-temporal land use land cover mapping of inaccessible remote areas which has served as a basic tool for conservation and management of natural resource. Land use land cover maps prepared using fine resolution satellite data are highly used for regional planning and development. In the present research paper, an attempt has been made to ascertain the changes occurred in land use in the Panshet catchment over the years and its impact on vegetation cover in the study area. It was observed that due to the spatio-temporal changes occurred, vegetation cover in the catchment is distressed.*

**Key words-** Catchment, GIS, Land use, Resolution, Remote sensing

**Introduction**:

In India, forestry sector is the second largest land use/ land cover after agriculture. The term land use is used to describe human uses of land, or immediate actions modifying or converting land cover (Sherbinin A. 2002), whereas land cover refers to the natural vegetative cover types, that characterize a particular area. Accurate assessment of land use land cover change is essential to generate information for sustainable development of natural resources and implementing various planning and monitoring agents (Prasad R. 2015). Mapping and change detection analysis of land use land cover studies using remote sensing and GIS technology has become an area of interest of researchers and planners. Land use land cover change detection is very fundamental requirement for better understanding of landscape dynamics during a known period for sustainable management of natural resources (Shelar A 2017).

Present research work focuses more on land use changes and its impact on forest cover in the selected study area. Along with commercial exploitation of forests, encroachment, or hacking and over grazing in the forest area was resulted in loss of valuable plant species. The vegetation in the catchment becoming thinner and diversity of plant life is much reduced now. Sometimes in the name of scientific management or environment friendly exploitation of forest also hamper the forest of the region. Due to the depletion of forest on the hill slopes the rate of soil erosion is accelerated which has been resulted in siltation of the reservoir (Gaikwad S, 2007). Loss of top fertile soil means that the cultivable areas are becoming unsuitable for agricultural activities. Soil loss and deforestation affecting the livelihood of rural population in many parts of the state.

**Study area:**

Panshet catchment is in Velhe tehsil of Pune district on the eastern flanks of Western Ghats. It is built in 1973 (reconstructed after breaking in 1961) on the river Ambi. The terrain consists of low-lying valley to high dissected ridges forming ridge-valley topography. The hill slopes are dotted by small villages with populations ranging from 100 to 400. This catchment lies just next to east of the crest line of the Western

Ghats at the altitude of about 600 m. The rainfall data shows variation from average annual 9000 mm at Western escarpment at village Dapsare, to 2100 mm at village Panshet where the dam is built. Distribution of rainfall becomes an important factor as it decides natural vegetation character in the valley (Karnadikar M, Dumale V Deshpande S 2015). In some parts, the terrain is very much broken with narrow valleys of less than half a km in extent separated by steep hills rising to altitudes of more than 950 m. The catchment area of this reservoir is 119.39 km$^2$ which include around 24 villages with combined population of around 5650 according to 2011 census. Geographical coordinates of the catchment are 18°17′44″ N to 18°23′01″ N latitude and 73°25′44″ E to 73°38′00″ E of longitude. In the study area many small, shorter perennial monsoon fed streams travel through steeper and more undulating topography before emptying into the Panshet dam. Abundant vegetation cover is found in the catchment and around 28 sq.km of the catchments area is under forest department. The people are poor and mostly marginal farmers depending heavily on traditional farming techniques according to the seasons. Previously the villagers cultivate paddy on the flat land in the valley, most of which are now submerged under the reservoir.

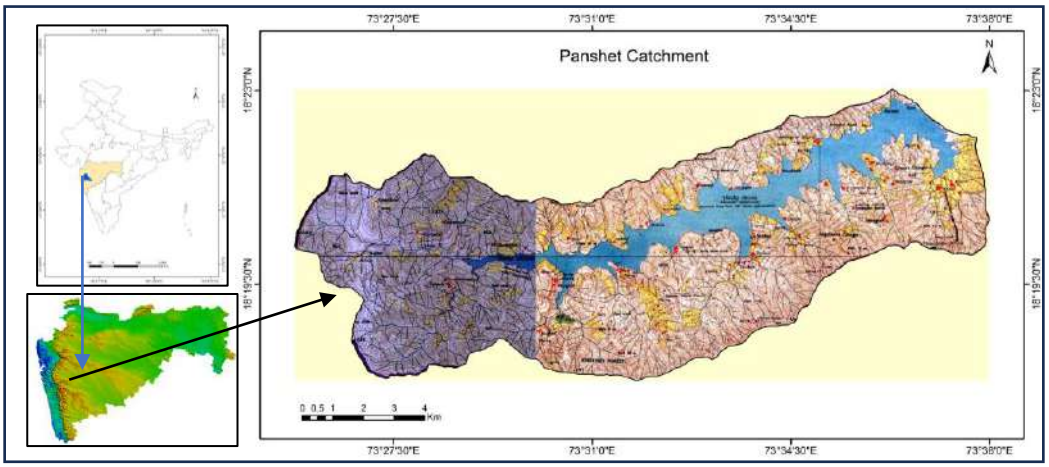



**Fig.1** Location of the study area

**Materials and methods-**

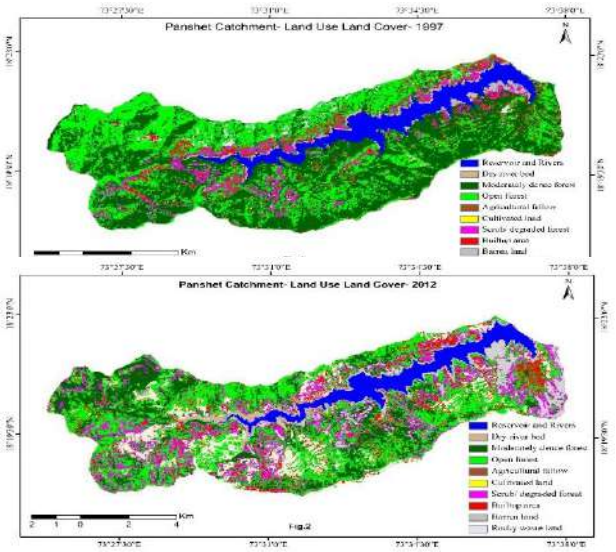
For the present research work Indian Remote Sensing Satellites (IRS) - 1C, and Resource-Sat-2 LISS III (Linear Imaging Self Scanning Sensor) of 23.5m spatial resolution MSS (Multi Spectral Scanner) data of 1997 and 2012 respectively, procured from NRSC, Hyderabad (India). This digital data is geometrically corrected using 47/F/7 and 47/F/11 Survey of India toposheet (1:50,000 scale) of the study area. Using the toposheet, study area is demarcated using Global Mapper software 11.03. In ERDAS IMAGIN 9.1 image processing software, false colour composite (FCC) of the study area is generated and classified in unsupervised manner. Area under major land use land cover category has been categorized into ten major classes (level II).

**Results and discussion**-

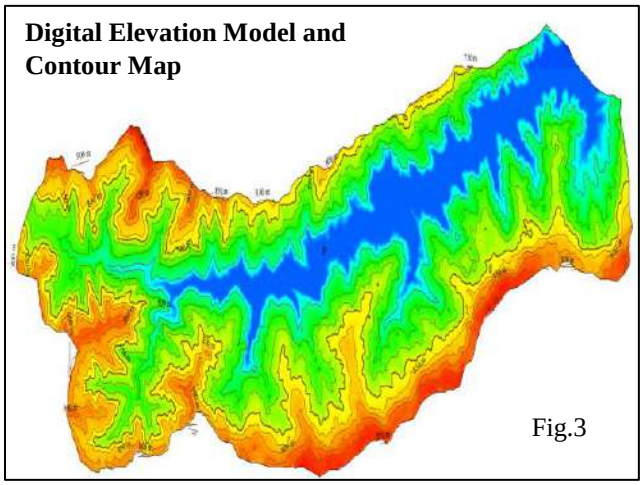
It can be seen from Fig 2, Fig 3 and LULC statistics table 1, noticeable changes are observed in land use categories particularly forest cover and land resources in the entire catchment. It is observed that moderately dense forest area towards the eastern part of catchment has reduced harshly (Fig 2). Within the span of 15 years, moderately dense forest, over around 29.28 sq. km is deteriorated. Similarly scrub or degraded forest area is increased from 4.86% in 1997 to 14.09% in the year 2012.

In India, forest resources are economically very important and still play significant role in livelihoods of rural societies. Forest in the study area affords a renewable source of timber, firewood, pasturage, and items of minor forest produce. It also provides shelter and means of livelihood and welfare to locals. Among

all the other land cover classes increase in wastelands, particularly increase in rocky wastelands is the result of decreasing vegetation cover on the sloping lands of eastern parts of the study area.




During the construction of dam around 1955, submerged region consisting with the paddy fields and the lowermost hill slopes with Mango and Harada trees deforested. With the deforestation of hill slopes, the top soil eroded rapidly in the face of heavy rainfall (Gadgil M 1979). The process is continued and it is noted that area under rocky wasteland in 1997 was 1.79 sq.km which was increased up to 12.78 sq. km in the year 2012. Hill slopes particularly western part of the Panshet is remote area and still covered by thick forests. In entire catchment agricultural practices are performed on the banks of the reservoir, as most of the area is characterised by hilly terrain and steep slopes hence negligible change is observed in cultivated land. During the field visits, it was observed that at some extent land is tilling by the local farmers with the agreement of state government. With the increase in population size in the villages of catchment, built up area has risen from 1.37% in 1997 to 7.34% in the year 2012.




In the present research work, an attempt has made to study the impact of land use transformation on vegetation cover of the study area. Field surveys were conducted to understand existing land use land cover pattern and types of vegetation found in the study area. Being a part of western ghats, Panshet catchment has varied types of vegetation influenced mostly by environmental conditions (Shelar A 2014).

In the catchment area, favourable climatic conditions with ample amount of annual rainfall, sustainable temperature range and humidity with altitudinal variation and rich soils have permitted varied forest variation in forest type. Along with commercial and ecological benefits, species of plants, shrubs and trees in the catchment also has certain medical value. The vegetation of Panshet catchment is divided into Grass-lands, Tropical moist-deciduous forest, Tropical semi-evergreen forest, and ravine forest (Bramhe S and Tetali P 1986). In entire catchment, total of 448 plant species were recorded which includes 131 species of trees, 75 species of shrubs, 70 species of climbers, 143 species of herbs, 23 species of grasses and 6 species of ferns (Karnadikar M., Dumale V., Deshpande S. 2015). *Acacia nilotica, Acacia catechu, Aegle marmelos, Bombax Ceiba, Anogeissus latifolia, Atalantia monophylla, Calotropics procera, Ficus glomerata, Gmlina arborea, Lnatana camara, Mangifera indica, Terminalia alata, Terminalia chebula*, are some the major plant species observed in the catchment abundantly. Hill slopes of the watershed and surroundings of settlements have a good human selective tree cover of *Mangifera indica*, *Terminalia alata*, *Eucalyptus camaldulensis, Azadirachta indica* and *Terminalia chebula*.

| Panshet Catchment | | LULC 1997 | | LULC 2012 | | Change between | | Average rate of change | |
|---|---|---|---|---|---|---|---|---|---|
| | | Area | | Area | | 1997 & 2012 | | | |
| No | Land cover class | sq.km | % | sq.km | % | sq.km | % | Km²/yr | %/yr |
| 1 | Reservoir and rivers | 10.75 | 9 | 9.32 | 7.81 | -1.43 | -13.28 | -0.1 | -0.89 |
| 2 | Dry river bed | 2.06 | 1.73 | 2.85 | 2.39 | 0.78 | 38 | 0.05 | 2.53 |
| 3 | Cultivated land | 0.06 | 0.05 | 0.4 | 0.33 | 0.34 | 620.91 | 0.02 | 41.39 |
| 4 | Agricultural fallow | 8.41 | 7.04 | 1.38 | 1.16 | -7.03 | -83.59 | -0.47 | -5.57 |
| 5 | Moderately Dense Forest | 51.8 | 43.38 | 22.51 | 18.86 | -29.28 | -56.54 | -1.95 | -3.77 |
| 6 | Open Forests | 35.92 | 30.08 | 37.01 | 31 | 1.09 | 3.03 | 0.07 | 0.2 |
| 7 | Scrub/ Degraded Forest | 5.8 | 4.86 | 16.82 | 14.09 | 11.02 | 189.97 | 0.73 | 12.66 |
| 8 | Barren Land | 1.17 | 0.98 | 7.55 | 6.33 | 6.38 | 543.11 | 0.43 | 36.21 |
| 9 | Rocky waste lands | 1.79 | 1.5 | 12.78 | 10.71 | 10.99 | 614.23 | 0.73 | 40.95 |
| 10 | Built up area | 1.63 | 1.37 | 8.76 | 7.34 | 7.13 | 436.44 | 0.48 | 29.1 |
| **TOTAL** | | **119.39** | **100** | **119.39** | **100** | | | | |

**Table 1**. Land use land cover data of the study area

Cash yielding or trees which has direct economic benefits like *Mangifera indica, Terminalia chebula, Azadirachta indica, Terminalia chebula* etc. are grown abundantly around the dwellings. Recently it was also observed that the focus is on growing nutrition-rich vegetables such as drumsticks and greens in the villager's backyards. Short term crops that would start to bear fruit in three-four months also preferred by the communities. Trees like *Ziziphus mauritiana, Acacia nilotica, Dendrocalamus structus* are also found abundantly. The nuts of *Terminalia chebula (hirda)* used extensively for tanning supported a flourishing industry. Weeds or shrubs like *Lantana camara and Carvia callosa* are spread over the large area due to biotic pressure. The upper hill slopes were clothed by rich natural forests of semi evergreen type, constituted into state owned forests reserves. These forests are hardly exploited due to the lack of proper transport facilities. The western ghats today harbor almost the entire forest wealth of Gujrat, Maharashtra, Goa, Karnataka, Tamilnadu and Kerala and these resources are already seriously in short supply (Gadgil & Prasad, 1978). In western ghats small and minor irrigation or hydroelectricity projects have led to serious deforestation in submerged and catchments areas. In Western Ghats, grasslands are also in trouble as much as forest. Timber plantations, expanding agriculture and the spread of invasive species have eaten extensive area of natural grasslands. It has resulted in rise in siltation of the reservoirs. This has long-range consequences on the catchments.

Existence of the scared groves in the catchment is one more significant characteristics of the study area. In many hilly parts of western Maharashtra, local tribal communities have traditionally protected forest patches which are dedicated to the local deity. Such forest patches reserved in the name of God (Local deity) are called as Sacred Groves. In India, Gadgil and Vartak (1975) are the pioneers of scientific study in the field of sacred groves and they have studied floristic and ethno-botanical aspects of sacred groves. Gadgil and Vartak (1981) documented 233 sacred groves in Maharashtra state. The sacred groves exhibit rich floristic diversity and are pockets of climax vegetation. These groves are associated with religious beliefs. It is supposed to be the abode of 'Forest God,' generally goddess and is known for a long. Most of the sacred groves in the present research area are situated on the source regions of the streamlets on which villagers are dependent for their water needs. Sacred groves helped to preserve many species of trees and climbers, orchids, ferns, birds, and animals in the catchment. In Panshet reservoir total twenty-eight sacred groves are reported (Bramhe S and Tetali.P 1986). In this catchment, *Kadtai, Jarvit-shmbhu,* at village Dapsare,

*Vardanidevi* at Kasedi, *Mahadev and Jogoba* at Givshi, Shirkai, and *Mhasoba* at Shirkoli and *Somjai* at Gondekhal are important. Most of the sacred groves although have diversity in vegetation few of them are now weakening. The thick tree canopy cover of sacred groves helps to minimize the flow of running water and the litter helps to retain the moisture. This vegetation cover thus regulates the water movement and protects perennial springs. The sacred groves in village Tekpole are devoted to Wardani- a water deity whereas Janni sacred grove is situated in Mangaon village. The sacred grove at village Tekpole is devoted to Waradani, a water deity- a goddess common along the crest of the Sahyadri (Bramhe S and Tetali.P 1986). Sacred grove one of the ways of expressing the gratitude of human being towards the vegetation where few important ecological and economic plant species or animals are conserved (Gadgil and Vartak, 1976). Although the removal of any plant or animal from the sacred grove is forbidden, with the change of time this belief has also changed and sacred groves and noted plant species are disappearing. Some of the sacred groves are reduced to a cluster of trees and climbers. The sacred groves in the extreme western parts of the catchments particularly in villages like Tekpole and Dapsare are well preserved and has now become the tourist centres.

**Conclusion**:

In India, forestry is obviously beneficial to agriculture and plays significant role of foster mother in promoting agro-industrial economy. Forests have made significant contribution to the Indian economy and to the State's domestic production. In recent studies, process of change detection analysis is mostly associated with environmental monitoring, resource conservation and understanding urban development. Comprehensive inventory of existing flora and fauna in the catchment and their relevance has studied by many scholars. It was found that anthropogenic stress or external threats are the major causes of loss in forest cover which mainly includes unscientific traditional agricultural methods, over grazing, construction activities, and uncontrolled tourism. Forest department in the study area has initiated plantation drive and planted species of Tectona grandis and Eucalyptus on deuterated lands. Judicious use and proper management of forest resources along with rehabilitation of degraded lands should be done on priority level. For the conservation of forests individuals, local communities, and various government and non-government organisation should go together with forest department.

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THE KONKAN GEOGRAPHER
Vol. No. 34, June/July 2025, ISSN No. 2277-4858
Impact Factor *(IIFS)* 8.125
(Interdisciplinary Peer Review Refereed Research Journal)

# Kharia Tribes and their Challenges

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**Research Paper Received on 12-06-2025 Edited & Accepted on 28-07-2025**

**Abstract:**

*An attempt is made in this paper to make Kharia tribes and their challenges for development analysis. Kharia is divided into three sub- groups Hill, Dudh and Dhelki Kharia. The Kharia tribe going through their life hacking challenges, different phases of development.*

*The main objectives of the paper are to bring out the challenges that comes in front of Kharia tribe for their development. The social and economic development of kharia tribes is correlated with their habitat, social structure, culture, sources of income and other activities. The way of living and day to day life activities is a detrimental factor for their growth and development.*

*The present study will be based on the sample survey where multi stage random sampling will be used. At first, a highly concentrated tribal Block of Simdega District will be chosen due to its large Kharia tribal population for the primary data generation. Some of the Blocks will be selected randomly for the study. The secondary data will be collected with the help of earlier publish government data, Research paper and internet. The total of 5 blocks will be selected for the field work from each block 10 villages and 4 families from each selected villages will be surveyed. Thus, a total of 200 families will be survey. A field work was undertaken to make in depth study of the socio-economic conditions with reference to the cultural diversity, geographical area. Further, some information was also collected from the grampardhan, socialist who are in connection with the village, forest with whom open discussion and interview may be done. A closed-ended questionnaire will be made for field test. Data about this study will be analyzed by a suitable statistical method other computer-based software like SPSS. The analysis and interpretation of data will be done from a geographical point of view. The detailed methodology will be illustrated in the respective chapters.*

*Above 60 percent of Kharia having major religion is Hinduism Kharia tribe is one of the earliest tribes inhabiting in different geographical areas spread over many districts in the Jharkhand. Kharia tribe is backward on every socio-economic aspect, and they live in one of most rugged area like forest and hilly area.*

**Keywords:** Kharia tribe, development, challenges.

## Introduction:

There are 32 tribal groups which is 26.2 percent (census of India 2011) of total population of Jharkhand. This region is the home land of aboriginal races such as the Santhals, Mundas, Oraons, Hos, Kharia, Bhumij, Birhors, etc. These indigenous people are known as adivasis literally meaning 'original settlers' or the earliest settlers. "Any tribe or tribal community or part of or group within any tribe or tribal Community as deemed under Article 342 is Scheduled Tribe for the purpose of the Indian Constitution". The Kharia tribal society is segregated into three broad segments, each having different occupations. These are named as Dudh, Dhelki and Hill kharia. The Hill kharia tribes are amongst the most ancient community and are also known as savar..They follows the clan system and some of clan are Kullu, Dundung ,Bilung, Kerketa, Hembrom and Tete etc.

The Kharia tribe lives in social and geographical like forest and hilly area due to this they have few opportunities for gainful employment resulting into poverty among them. For livelihood they heavily depend on forest & forest product, their main activity are honey collection, collection of tubers and herbs as food and medicine. They are also practicing agriculture. In the daily life animal husbandry is one of their supplements to the agriculture. They cultivate crops like marua (Ragi), maize, vegetables etc. Their lands are of two types namely Tanr land and Don land. They cultivate mainly paddy in Kharif season and pulses , Mustered and

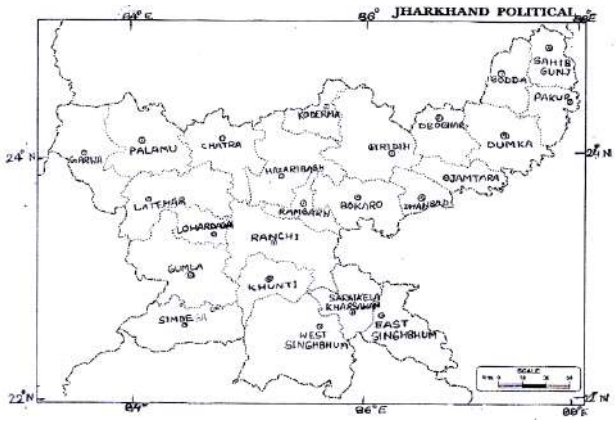
rapeseed during the Rabi season. Now day some of them has adopted labour work as means of livelihood and money earning.

**Study Area :**

Study area is Simdega District which is situated in the south western part of the state. Jharkhand has 24 districts. It borders with Odisha and Chhattisgarh states. It comprises of the area, which was erstwhile the Simdega subdivision of the district Gumla and was created on 30th April 2001. It is surrounded by Gumla district in the north, Khunti in the north-east and west Singhbum district in the east and district of Chhattisgarh in the west and district Sundargrh of Odisha in the south. The district is situated between $20^0$ 10 min to $20^0$ 40 min North and $84^0$ 0 min to $84^0$ 34 min. East. It has an average elevation of 418m .The district Comprises10 blocks and they are:-

(i) Simdega (ii) Kurdeg, (iii) Bolba (iv) Thethaitangar (V) Kolebira. (VI) Bano (vii) Jaldega (viii) Pakartanr (ix) Bansjor and (x) Kersai. The district comprised an area of 3761.2 sq. km and forest Area cover 1194.50 sq. km (31. 75%). It has a population 5,99,813 (as per 2011 census). The average population density is 136.74 person per sq. km. Urbanization is very poor with 6.6 % population only and Simdega is the only town in the district. District is primarily settled by the scheduled Tribes with 70.2% population, which is the highest among all the districts of Jharkhand closely followed by Gumla district with 67.2% ST population. Majority of the scheduled Tribes at Simdega districts belong to the Christian faith. Major tribal groups in the district are Oraon, kharia and Munda. Study Area.

**Map of Jharkhand** **Map of Simdega District**





**The Population distribution as per the census of India 2011 is given below:**

| Block Name | Total/Rural/ Urban | Total persons | Male | female |
|---|---|---|---|---|
| Pakartanr | Rural | 37562 | 18942 | 18620 |
| Kersai | Rural | 39276 | 19593 | 19683 |
| Bansjore | Rural | 25527 | 12853 | 12674 |
| simdega | Rural | 72203 | 36063 | 36140 |
| Kurdeg | Rural | 48049 | 23900 | 24149 |
| Bolba | Rural | 30666 | 15181 | 15485 |
| Thethaitangar | Rural | 87426 | 43513 | 43913 |
| Kolebira | Rural | 71368 | 35947 | 35421 |
| Jaldega | Rural | 64324 | 32175 | 32149 |

| | | | | |
|---|---|---|---|---|
| Bano | Rural | 80479 | 39881 | 40598 |
| Nagar Panchayat | Urban | 42933 | 21857 | 21076 |
| Simdega District | Total | 599813 | 299905 | 299908 |
| | Rural | 556880 | 278044 | 278832 |
| | Urban | 42933 | 21857 | 21076 |

*Source :CENSUS 2011 REPORT(Provisional Population)*

Major parts of the geographical area of the district are formed of red laterite acidic soil. Upland has generally covered by Morum and stone. The landscape is formed of hills and undulating plateau. The inhabitants of this area depend primarily on agriculture and forest products for their livelihood. It has about 32% of forest cover area. The major trees are Sal, Gamhar, Jackfruit, Blackberry, Mango, Bamboo and Neem etc. Important forest products are Saal seeds, Cocoon Lac, Tendu leaves, Karanj and Chiraunji etc. Almost 90% of the total population depends on agriculture. The main crop of this area is paddy, millets, mustard, niger and maize are also quite popular. Total cultivated land is about 134024 hect out of which only 16367-hect is irrigated. The agriculture is mainly depended on rainwater. The major rivers of this district are Sankh, Deo, Girwa, and Palamara. Sankh is the largest river among them.

**Objective:**

The social and economic development of kharia tribes is correlated with their habitat, social structure, culture, sources of income and other activities. The way of living and day to day activities is a detrimental factor for their growth and development. The main objective of the paper is to find out the challenges comes out in the way of development of the Kharia tribe .

**Research Design And Methodology:**

The present study will be based on the sample survey where multi stage random sampling will be used. At first, a highly concentrated tribal Block of Simdega District will be chosen due to its large Kharia tribal population for the primary data generation. Some of the Blocks will be selected randomly for the study. The secondary data will be collected with the help of earlier publish government data, Research paper and internet. The total of 5 blocks will be selected for the field work from each block 10 villages and 4 families from each selected villages will be surveyed. Thus, a total of 200 families will be survey. A field work was undertaken to make in depth study of the socio economic conditions with reference to the cultural diversity, geographical area. Further, some information was also collected from the grampardhan ,panchayat sachiv, socialist who are in connection with the village, forest with whom open discussion and interview may be done. A close ended questionnaire will be made for field test. Primary data will be collected at the village level with the help of questionnaire apart from this interview and scheduled techniques also will be use. Physical aspect will be obtained by relevant top sheet published by survey of India. Emphasize will be given to cover wholesome and spatial settlement of kharia tribe. Secondary data will be taken from district census hand book, socio-economic review and statistical abstracts, Gazetteers of Simdega district and other government and private institutes. Data from census of India, Economic survey of India, government reports, books and magazines, published and unpublished research article will be used as Secondary source of data, which will be helpful in the present study. Internet will be also use as a valuable source of information.

**Discussion:**

Jharkhand is tribal dominated state and its development is directly related to development of its tribal population. Jharkhand is rich but its people are poor, to make state developed its peoples need to be developed first. Kharia tribe is one of the earliest tribes inhabiting in different geographical area spread over many district in the Jharkhand. Kharia tribe is backward on every socio-economic aspect and they live in one of most rugged area like forest and hilly area. There are 1,211,846 total ST population working as marginal worker where 24,101 total Kharia work as Marginal worker. Out of total Kharia 23,466 are rural and only 635 urban Kharia populationwork as marginal worker. Habitat and economy of Kharia tribe of are important

for regional planning and socio-economic development of Simdega district as here is good population of this tribe. Majority population of Simdega live in rural area there for the study is more important for planned urbanization and modernization. Kharia population 1,96,135 are educated ,where 180,179 rural population and 15,956 urban population of Kharia are educated . This value shows that urbanization will be in bottom .

Despite having good natural resource industrialization is very less which indicate backwardness about the district. This tribe is losing its identity as they are unable to keep the pace with modern world. So this study is important for the development of kharia tribe and other tribes living the same situation which may open a way to develop human resource. The present work will add to the knowledge about recent prevailing socio economic condition of tribal geography of Jharkhand. It will help in knowing various factors affecting the life of Kharia tribe. Through this study the reason for geographical isolation of Kharia tribe can be understood. This work may help in identifying the reasons for their backwardness in many areas like agriculture, animal husbandry, employment, education & health and provide possible solution to alleviate them. Most of developmental work taken by the government and NGOs for Kharia tribe is based up published data like censes etc. It has been often seen that many tribal welfare programme don't yield desire result due to lack of knowledge about their geographical habitat and culture.

This research work may serve in understanding the need and problems of Kharia tribe. It can enable the policy-maker to formulate an effective development plans for wholesome growth and development of this community. As tribal like to live in harmony with nature i.e. forest they keep on maintaining the required ecological balance which is the need of time as we are facing the environmental problems like global warming and raise in other pollution level. Thus current research work will intend to contribute in Anthropo-geographical knowledge about the Kharia tribe in Simdega district of Jharkhand.

The indigenous farming community makes careful observation about their land, agro-climate condition. Dissipation of traditional knowledge in oral form to their next generation can be very useful in local situation as now days indigenous traditional knowledge are used to find the solution to the existing problem like in medicine, agro-forestry. The study will aid in conservation of biodiversity and environments. Through this study the problems of kharia tribe may be identified to some extent which can be useful in protection of their social and culture identity.

**Major Finding**:

Agriculture is a major source of income for this tribe. They are depended on it for food, security, growth and employment. They are practicing mono-cropping system of agriculture which fulfills only food security for half of the year for their family due to small landholdings. They mitigate their rest of need by working on nearby cities as daily wage worker. Apart from this many families are still dependent on forest and forest products for earning and livelihood. The education , working power , social life style is the main challenges of the Kharia population .They have lived in isolated condition for centuries largely untouched by society around them. There exclusion affected their socio-economic and cultural development.

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THE KONKAN GEOGRAPHER
Vol. No. 34, June/July 2025, ISSN No. 2277-4858
Impact Factor *(IIFS)* 8.125
(Interdisciplinary Peer Review Refereed Research Journal)

# Fire Hazards in Kolkata : Trends, Causes, Impacts and Management Strategies (April 2020–March 2025)

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**Research Paper Received on 17-06-2025 Edited & Accepted on 20-07-2025**

**Abstract:**

*From April 2020 and March 2025, Kolkata, one of India's most densely populated metropolitan cities, witnessed a substantial rise in fire incidents. These events, driven primarily by human negligence, infrastructural inadequacies, and improper safety compliance, posed significant threats to human lives, infrastructure, and the environment. This paper investigates the spatial and temporal patterns of fire outbreaks in Kolkata, classifies the types of fires, identifies high-risk zones, and explores both the impacts and the shortcomings of current fire management systems. Recommendations for improved fire safety and urban planning are also proposed.*

**Key words:** Fire Hazards, Urban Risk, Disaster Management

## Introduction:

Fire hazards are categorized as man-made disasters, arising due to human error, technological failure, or socio-urban negligence. They result in not just material damage but also in substantial human and ecological losses. Kolkata, as India's third most populous metropolitan region, faces increasing vulnerability to such hazards due to its rapid urbanization, congested neighborhoods, outdated infrastructure, and inadequate enforcement of fire safety regulations. This research examines data collected from 2020 to 2025 to understand the root causes, types, effects, and mitigation strategies relevant to Kolkata's fire hazard scenario.

## Study Area:

Kolkata, the capital of West Bengal, is located in eastern India, within the lower Ganges delta, approximately 75 km west of the international border with Bangladesh. The city stretches along the east bank of the Hooghly River, with geographical coordinates of **22.5667°N and 88.3667°E**. It is bordered by North 24 Parganas to the north and east, South 24 Parganas to the south, and the Howrah district across the Hooghly River to the west. The city falls under the jurisdiction of the Kolkata Municipal Corporation (KMC) and covers an area of **205 sq. km**. KMC is administratively divided into **144 wards**, grouped into **16 boroughs**.

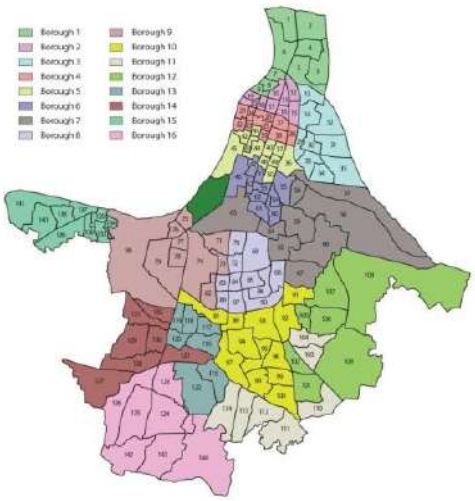
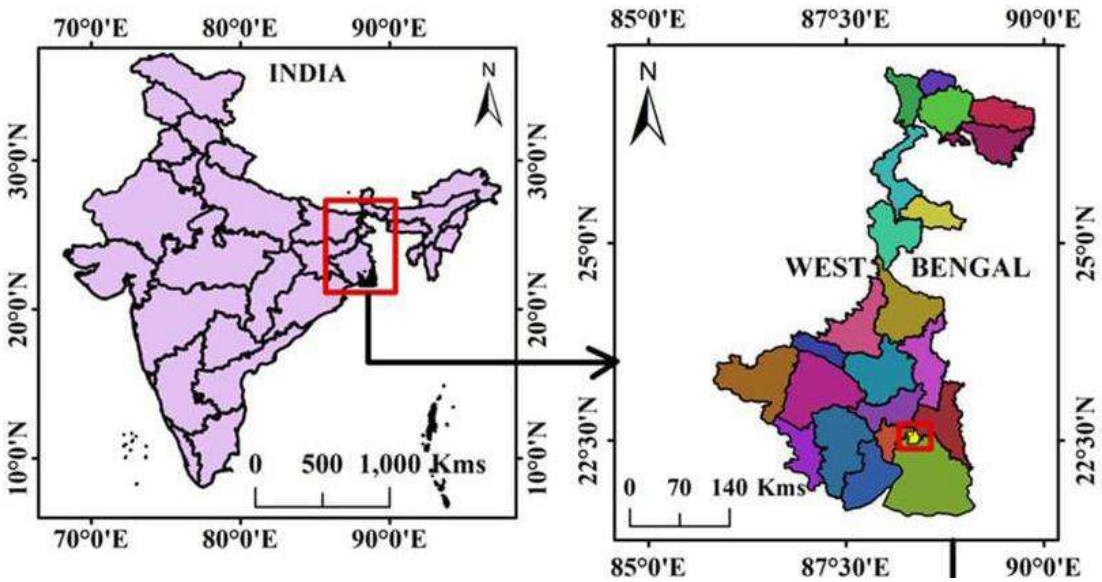



**Fig 1: Map of The Study Area**




**Methodology:**

The study utilizes secondary data sources, including government reports, newspapers, academic articles, and tabulated incident data. Incidents were analyzed year-wise and classified by fire type (as per NFPA classes A, B, C, D, K). The study incorporated cartographic risk zonation by KMC wards to determine high-, medium-, and low-risk areas. Patterns in causes, locations, and consequences were analyzed using charts and comparative tables.

**Objectives:**

- To identify the major causes of fire incidents in Kolkata.
- To analyze temporal and spatial trends in fire outbreaks.
- To assess the impact of these fires on people and infrastructure.
- To categorize fire incidents by type and frequency.
- To suggest strategies for fire prevention and urban risk reduction.

**Research Problem:**

Kolkata has witnessed a sharp rise in fire-related incidents between 2020 and 2024, attributed largely to human negligence, inadequate fire safety infrastructure, and unchecked urban growth. Despite being the third most populous metropolitan city in India, a significant portion of its structures—particularly slums, marketplaces, and old buildings—lack basic fire prevention systems. The growing frequency of fires due to electrical faults, gas explosions, and unsafe material storage has resulted in severe property damage, loss of life, and homelessness. Government intervention and enforcement of safety regulations remain insufficient, exacerbating the crisis. This research aims to investigate the patterns, causes, and impacts of fire hazards in Kolkata and assess the effectiveness of current fire safety measures. It also seeks to identify high-risk zones and promote sustainable fire prevention strategies.

**Major Causes of Fire Hazards:**

The fire incidents stem from multiple direct and indirect causes:

- **Electrical faults**: Poor wiring and overloading of circuits were the most common causes.
- **Gas cylinder explosions**: Especially in slums and commercial kitchens.
- **Improper storage of flammable materials**: Common in markets, factories, and unauthorized godowns.
- **Negligence and human error**: Unattended cooking, smoking near combustibles, and illegal construction practices.
- **Infrastructure bottlenecks**: Congested access roads and lack of fire hydrants in many areas.

**Impact:**

Fires in Kolkata between 2020 and 2025 had wide-ranging and severe impacts. Immediately, they caused loss of life, injuries, and health complications such as burns, respiratory issues, and suffocation from toxic smoke, as seen in the March 12, 2022 Free School Street incident. Socially, fire incidents led to large-scale displacement, psychological trauma, and restricted access to basic necessities like food and shelter. The environmental consequences were equally alarming, with fires releasing carbon dioxide and other pollutants into the air and contaminating nearby water bodies, harming both terrestrial and aquatic ecosystems. Economically, the destruction of homes, shops, and infrastructure inflicted heavy financial losses on individuals and required substantial government expenditure for firefighting and rehabilitation. Administratively, weak governance, poor enforcement of safety norms, and inadequate compensation mechanisms hindered effective response and recovery. Politically, repeated fire outbreaks fueled public dissatisfaction and eroded trust in authorities such as the Kolkata Municipal Corporation. Health-wise, at least 21 people were injured and 29 affected, with long-term ailments like asthma and eye irritation reported. In the short term, fires degraded air and water quality and destroyed habitats, while long-term effects included disruption of the carbon cycle, biodiversity loss, and enduring threats to public health.

**Result and Discussion**:

Fire hazards pose a significant threat to urban safety, often resulting in extensive damage to property, loss of life, and displacement of communities. This report provides a detailed account of major fire incidents that occurred in Kolkata between 2020 and 2025 year wise. By analyzing data from various city wards, the report aims to identify patterns in the causes, locations, and consequences of these hazards. The majority of the reported incidents were due to short circuits, followed by cylinder blasts and other combustible sources. The findings emphasize the urgent need for stricter fire safety regulations, improved infrastructure, and public awareness to mitigate the risks associated with urban fire outbreaks.

**Table:1 Fire Incident Statistics and Key Wards Affected (April 2020 – March 2025)**

| SL NO. | YEAR (APRIL TO MARCH) | NO OF INCIDENCE | MAIN WARDS AFFECTED |
|---|---|---|---|
| 1 | 2020-2021 | 15 | 23,131,42,57,66,73,11,7,118,2,29,99,45,29,16 |
| 2 | 2021-2022 | 20 | 46,63,44,57,135,24,44,82,33,58,90,2,60,58,44, 58,58,120,81,92 |
| 3 | 2022-2023 | 5 | 58,63,71,2,28 |
| 4 | 2023-2024 | 15 | 66,22,45,44,4,90,45,47,24,13,44,61,108,31,34 |
| 5 | 2024-2025 | 25 | 79,5,63,107,42,37,94,85,24,86,34,66,109,81,1 04,91,4,29,65,58,35,103,73,34 |
| | **Total** | **80** | |

From April 2020 and March 2025, (Table 1, Fig 2) a total of 80 fire incidents were reported across various wards of Kolkata. The number of incidents varied annually, with the highest (25) recorded in 2024-2025 and the lowest (5) in 2022–2023. Several wards appeared multiple times over the years, indicating recurring vulnerability-notably wards 44, 58, and 66.

The fluctuations suggest possible changes in fire safety measures, reporting efficiency, or seasonal/environmental factors. The data highlights the need for targeted fire prevention efforts in frequently affected areas.

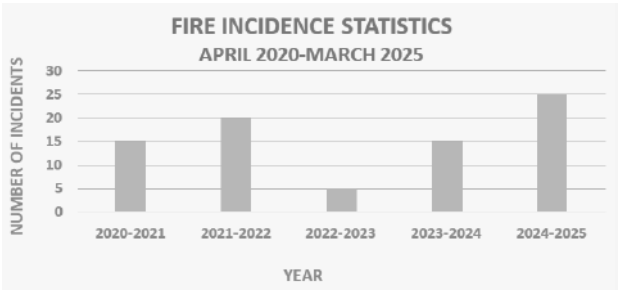



**Fig 2**

**Table: 2: Types of Fire Incidents in Kolkata (April2020-March 2025)**

| Fire Types | | | | | |
|---|---|---|---|---|---|
| **YEAR** | **A** | **B** | **C** | **D** | **K** |
| **2020-2021** | 1 | 1 | 10 | - | 3 |
| **2021-2022** | - | 3 | 10 | 4 | 3 |
| **2022-2023** | - | 2 | 2 | - | 1 |
| **2023-2024** | - | 3 | 7 | - | 5 |
| **2024-2025** | 1 | 2 | 11 | 2 | 9 |

The table (Table:2, Fig 3) summarizes types of fire incidents in Kolkata from April 2020 to March 2025, categorized by fire classes A to K. Class C (electrical fires) consistently recorded the highest number of incidents across all years, peaking at 11 in 2024–2025. Class K (kitchen fires) also showed an increasing trend, with a notable rise to 9 incidents in 2024–2025. Class A (ordinary combustibles) and Class B (flammable liquids) showed low and fluctuating frequencies. Class D (metal fires) had very few occurrences, appearing only in two years. Overall, electrical and kitchen-related fires were the most frequent and persistent types reported during this period.

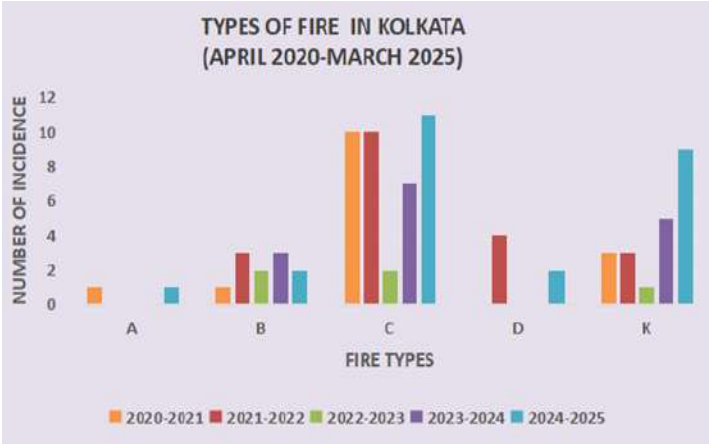



**Fig: 3**

**Table 3: Consequences of Fire Outbreaks in Kolkata (April 2020-March 2025)**

| Year | Total Cases | Homeless | Hospitalized | Death | Shop/Factory/ Room/Godown |
|---|---|---|---|---|---|
| March2020-April2021 | 15 | 182 | - | 13 | 14 |
| March2021-April2022 | 20 | 51 | 15 | 7 | 45 |
| March2022-April2023 | 5 | - | 1 | 2 | 120 |
| March2023-April2024 | 15 | 120 | 6 | 2 | 3 |
| March2024-April2025 | 25 | 460 | - | 5 | 34 |

The table (Table: 3, Fig 4) outlines the impact of fire incidents in Kolkata from March 2020 to April 2025. The number of total fire cases fluctuated yearly, peaking at 25 in 2024–2025. The highest number of people rendered homeless was also in 2024–2025, with 460 individuals affected. Hospitalizations were reported most in 2021–2022 (15 cases), while the highest number of deaths occurred in 2020–2021 (13

deaths). The year 2022–2023 saw minimal reported human impact but significant property damage, with 120 shops / factories / rooms / godowns affected. Overall, fire outbreaks led to varying degrees of displacement, injury, fatality, and structural damage throughout the five year period.

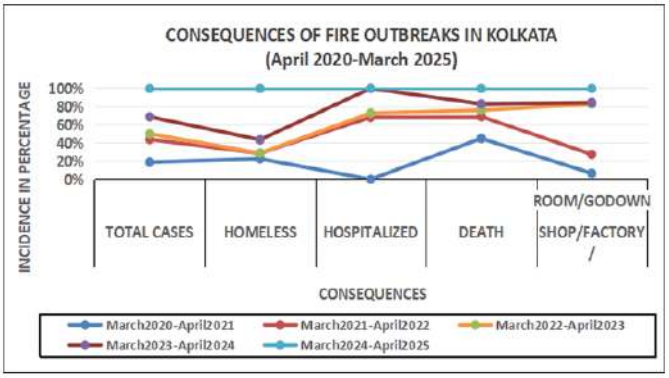



**Fig: 4**

## Table: 4 Ward-Wise Fire Risk Mapping In Kmc (April 2020–March 2025)

The document presents a ward-wise fire hazard zonation for Kolkata Municipal Corporation (KMC) based on data from April 2020–March 2025 (Table: 4, Fig 5). The wards are categorized into three zones by risk level. **Zone 1** includes the majority of wards and is designated as **Low Risk**, suggesting fewer fire incidents or better infrastructure. **Zone 2**, marked as **Medium Risk**, includes a moderate number of wards with relatively higher vulnerability. **Zone 3**, labeled **High Risk**, comprises the smallest number of wards but indicates areas with the greatest fire risk, likely due to dense settlements, poor fire safety infrastructure, or frequent incidents. This classification helps prioritize fire prevention and emergency response planning. Using ward-level data, KMC areas were classified into three risk zones based on frequency and severity of fire incidents:

| ZONES | WARD NUMBER | RISK ZONATION |
|---|---|---|
| ZONE 1 | 1,3,5,6,8,9,10,12,14,15,17,18,19,20,21,25,26,27,30,32,35,36,38,39, 40,41,43,48,49,50,51,52,53,54,55,56,59,62,64,67,68,69,70,72,74,75 ,76,77,78, 80,83,84,87,89,93,95,96,97,98,100,101,102,103,105,106,110,111,11 2,113,114,115,116,117,119,121,122,123,124,125,126,127,128,129,1 30,132,133,134,136,137,138,139,140,141 | LOW RISK |
| ZONE 2 | 7,11,13,16,22,23,28,31,33,37,46,47,60,61,65,71,79,82,85,86,88,91, 92,94,99,104,107,108,109,118,120,131,135 | MEDIUM RISK |
| ZONE 3 | 2,4,24,29,34,42,44,45,57,58,63,66,73,81,90 | HIGH RISK |

**Zone 1 (Low Risk)**: Majority of wards with modern infrastructure and fewer incidents.

**Zone 2 (Medium Risk)**: Includes areas with moderate density and occasional hazards.

**Zone 3 (High Risk)**: Comprising wards such as 34 (Beleghata), 42 (Burrabazar), 66 (Topsia), these areas suffer from overcrowding, illegal storage practices, and poor access for emergency services.

**Key High-Risk Wards (Zone 3)** Beleghata (Ward 34), Tangra (Ward 66), Burrabazar (Ward 42),Rajabazar (Ward 29). These zones should be prioritized for safety audits, fire drills, and infrastructure retrofitting.

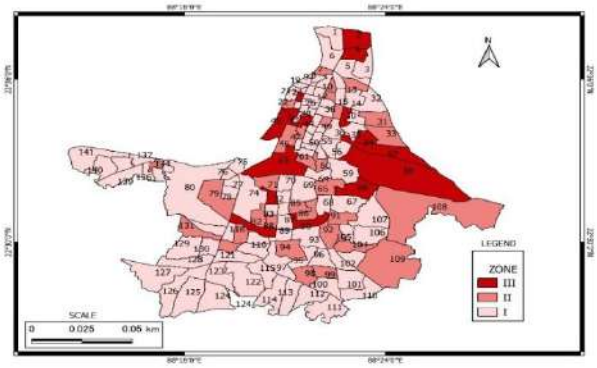



**Fig 5 Ward Wise Fire Risk Zonation Mapping in Kmc (April 2020-March 2025)**

**Table: 5: List Of Fire Stations In Kolkata**

| SI NO. | NAME OF THE FIRE STATION | LOCATION | WARD NUMBER |
|---|---|---|---|
| 1. | Fire Brigade Head Quarter: | Mirza Ghalib Street, Kolkata. | 52 |
| 2. | Baisnabghata | Baisnabghata, Patuli | 110 |
| 3. | Behala | Diamond Harbour Rd, Silpara | 119 |
| 4. | Canal West | Manicktala, Gouri Bari, Kolkata | 15 |
| 5. | Central Avenue | Chittaranjan Avenue. College Square | 44 |
| 6. | Cossipore | Located in Cossipore Rd. | 1 |
| 7. | Dumdum | Located in Dumdum Cantonment | 44 |
| 8. | Kalighat | Located in Kalighat, Hazra Rd | 83 |
| 9. | Salt Lake | Located in Salt Lake, Sector V, Bidhannagar. | 23 |
| 10. | Tollygunge | Located in Tollygunge, Bansdroni, | 93 |
| 11. | North Barrackpore | Located in Badamtala Ichhapur | 6 |
| 12. | Alifnagar | Metiabruz N.S. Road | 138 |
| 13. | Lal Bazar | India Exchange Place | 45 |
| 14. | Gardenreach | Garden Reach Road | 135 |
| 15. | Manicktala | Kankurgachi, Canal W Rd, Manicktala | 32 |
| 16. | Newtown | Located in Action Area 1C | |
| 17. | Lake Town | Block A, Lake Town | 35 |
| 18. | Masterda Surya Sen | Bansdroni, Kolkata | 93 |
| 19. | Pragati Maidan | Basanti Highway, Dhapa, Kolkata | 58 |
| 20. | Nimtala | Nimtala, Jorabagan | 24 |

Fire zonation is a crucial tool for enhancing urban fire safety and disaster management. It helps authorities identify high, medium, and low-risk areas, enabling efficient allocation of emergency services, fire stations, and firefighting resources. Urban planners use this data to enforce safer building codes and land use policies, especially in vulnerable zones. It also assists insurance companies in risk assessment and premium determination. For the public, fire zonation increases awareness and encourages preventive measures. Moreover, it supports the development of targeted evacuation plans and emergency response strategies, ultimately reducing the impact of fire incidents on life and property.

The list provides names, locations, and ward numbers of 20 fire stations across Kolkata, highlighting their geographic spread (Table 5, Fig 6). Key areas like Salt Lake, Tollygunge, and Central Avenue are covered, showing strategic placement in both central and suburban zones. Overall, the data supports analysis of fire safety infrastructure distribution across the city.

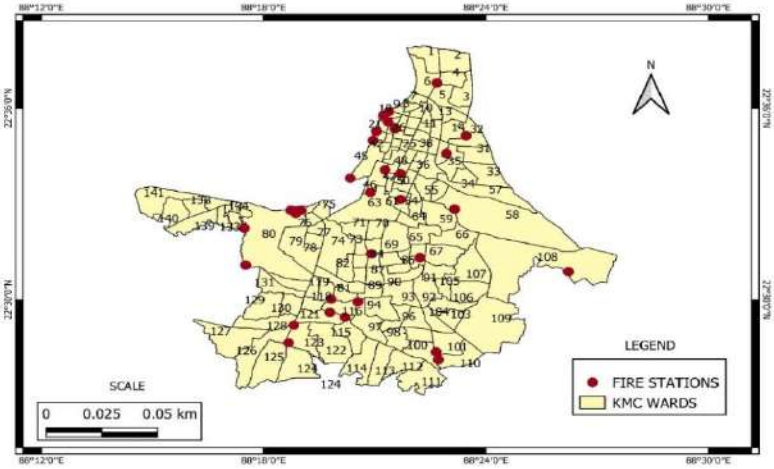



**Fig: 6 Location of Fire Stations of Kmc**

Fire management in Kolkata involves a multi-faceted strategy to tackle the city's fire safety challenges arising from its dense urban layout, aging infrastructure, and limited public awareness. Despite the presence of regulations mandating fire safety systems and certifications, widespread non-compliance and illegal constructions remain major obstacles. Key initiatives such as GIS-based risk mapping, equipment upgrades, and public training programs are being implemented to enhance preparedness and response. Both pre- and post-fire measures—ranging from infrastructure development and education to emergency relief and rehabilitation—are crucial for minimizing fire-related damage and building long-term resilience.

**Future Preparedness :**

To reduce fire hazards in Kolkata, strict enforcement of fire safety regulations in residential, commercial, and industrial areas is essential. Regular inspections, especially in high-risk zones like slums and markets, should be mandated. Public awareness campaigns and community training on fire prevention and emergency response can greatly enhance preparedness. Installing fire alarms, extinguishers, and proper electrical systems must be prioritized. Additionally, the government should develop rapid response units and invest in modern firefighting equipment to minimize damage and casualties in future incidents.

**Conclusion :**

The analysis of fire incidents in Kolkata from 2020 to 2025 reveals a troubling increase in frequency and severity, with major causes including short circuits, gas cylinder explosions, and storage of inflammable materials. These incidents are concentrated in vulnerable areas such as slums, markets, hospitals, and factories, where fire safety infrastructure is either lacking or poorly maintained. The immediate impacts include loss of life, injuries, and displacement, while the long-term consequences involve economic hardship, environmental degradation, and public health issues. Several fires led to the destruction of hundreds of homes and shops, affecting thousands of people. The recurring nature of these events points to systemic negligence and inadequate urban planning. Administrative inefficiencies and delayed responses have worsened the situation, eroding public trust. The findings emphasize the urgent need for stricter enforcement of fire safety norms, community awareness programs, and resilient infrastructure development. Without proactive intervention, Kolkata remains highly susceptible to future fire-related disasters. Kolkata's fire management system faces persistent hurdles due to rapid urbanization, outdated infrastructure, and administrative inefficiencies. While progress has been made in upgrading equipment and raising awareness, a robust, integrated strategy is needed. The city must focus on smart urban planning, strict enforcement of fire norms, and inclusive community engagement to build a safer, more resilient Kolkata.

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THE KONKAN GEOGRAPHER
Vol. No. 34, June/July 2025, ISSN No. 2277-4858
Impact Factor *(IIFS)* 8.125
(Interdisciplinary Peer Review Refereed Research Journal)

# Assessment of Socio-Economic Impacts of the NH-66 Manohar Parrikar Bypass in Canacona, Goa : A People's Perspective

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**Research Paper Received on 12-06-2025 Edited & Accepted on 15-07-2025**

**Abstract :**

*This research investigates the socio-economic impacts of the NH66 Manohar Parrikar Bypass in Canacona-Goa, emphasizing community perceptions, displacement, and livelihood changes. Employing a mixed-methods approach; combining surveys, interviews, and spatial analysis; the study captures the lived experiences of local residents. While the bypass has improved connectivity and regional accessibility, it has also resulted in property loss, business disruptions, and health-related concerns. The findings highlight the dual nature of infrastructure development and underscore the need for inclusive, people-centric planning. The study also identifies a critical gap in environmental assessment, offering scope for future research on ecological consequences.*

## Introduction:

'The development of road infrastructures is linked with socio-economic development of the country' (Aryan et al., 2024). Globally, countries are making significant investments in road networks to support and accelerate economic growth. India is home to the second-largest road network in the world, stretching across more than 6.386 million kilometres (MoRTH, 2021). However, the rapid expansion of road infrastructure is largely driven by a surge in private vehicle ownership which comes with considerable environmental costs, ultimately affecting human well-being (Wilson & Naseer, 2021).

The NH66 Manohar Parrikar Bypass, a major infrastructure project passing through Canacona in South-Goa, was initiated to ease traffic congestion and improve connectivity along the coastal highway corridor.[1] While the project is often viewed as a symbol of progress and development, the project has also raised critical concerns regarding its socio-economic consequences; particularly for communities situated along its route. The bypass has led to noticeable changes in land use patterns while also impacting livelihoods, causing displacement, and altering the daily lives of residents.

Despite these effects, much of the existing discourse remains focused on technical specifications or policy-level evaluations, with limited engagement in understanding how local communities perceive and experience these transformations. This study seeks to address that gap by examining the socio-economic impacts of the bypass through a people's perspective. Adopting a community-based approach, it aims to capture the lived experiences, concerns, and aspirations of Canacona's residents, thereby contributing to a more inclusive and socially responsive model of infrastructure development.

## Aim & Objectives:

To investigate the socio-economic impacts of the NH66 Manohar Parrikar Bypass project in Canacona, Goa, with a focus on displacement, livelihood changes, and community perceptions, highlighting the lived experiences of affected residents.

**Objectives:**

1. To analyse the socio-economic consequences of the bypass on the livelihoods, mobility, and quality of life of residents in the study area.

**Literature Review:**

Transport plays a fundamental role in facilitating economic development and fulfilling the needs of nations, regions, and urban centres (Vitkūnas et al., 2021). Robust transportation infrastructure enhances the flow of goods by improving both volume and efficiency, thereby supporting broader socio-economic progress (Wolff, M.; Abreu, C.; Caldas, 2019). A well-established body of literature highlights a strong link between the expansion of highway networks and regional economic growth (Rathee, Chetna., 2025).

However, alongside these developmental benefits, several studies have also documented the negative externalities associated with road infrastructure development. Increased road capacity often leads to higher vehicular activity, which in turn contributes to environmental issues such as air and noise pollution and significant alterations to natural landscapes (Centurião et al., 2024). Furthermore, road construction can have direct health implications for local residents and communities living along highway corridors (Sackey et al., 2023). Beyond environmental and health concerns, such infrastructure projects frequently generate socio-economic disruptions, particularly in the form of displacement, livelihood loss, and changes to community dynamics.

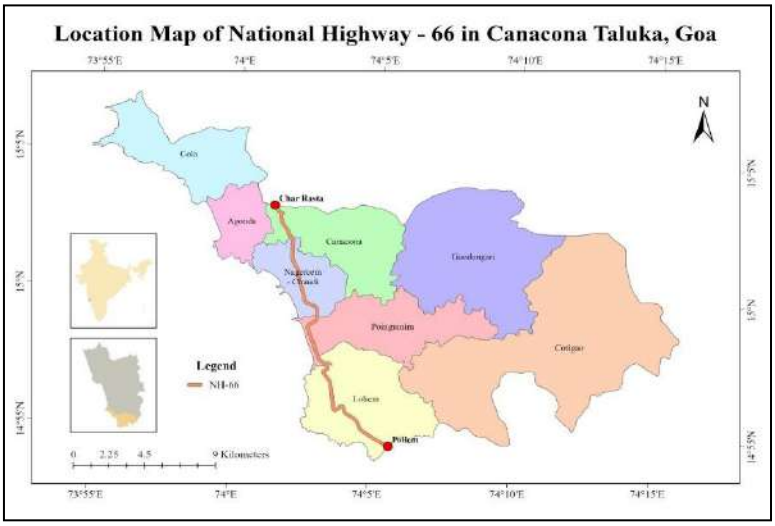
**Database & Methodology:**

This study adopts a mixed-method approach, combining both qualitative and quantitative research methods for comprehensive data collection and analysis. Primary data was gathered through surveys, interviews, and focus group discussions conducted with residents of the study area, offering direct insights into community experiences and perceptions. To assess the socio-economic impacts of the Manohar Parrikar Bypass, interviews were conducted with 20 residents living near the project site. In addition, secondary data was obtained from various sources such as research articles, newspaper reports, government publications, official websites, and other relevant literature.

The research also includes statistical data tabulation and the use of cartographic techniques for visual representation. Maps, charts, and graphs were created to support the analysis. Spatial data was processed and maps were prepared using QGIS 3.40 LTR software, along with satellite imagery and Google Earth.

**Study Area:**

Canacona, pronounced *Kankon* in Konkani, is the southernmost taluka of the Indian state of Goa. Located in South Goa district, it is one of the five talukas that make up the region. Geographically, Canacona holds a strategic position—bordered by Quepem taluka to the north, Sanguem to the northeast, the state of Karnataka to the south, and the Arabian Sea to the west. The taluka's administrative centre is the town of Chaudi[3].




The Manohar Parrikar Bypass, also referred to as the Canacona Bypass, is a major infrastructure project in Canacona, Goa, designed to improve connectivity and alleviate traffic congestion along National Highway 66. The bypass

provides a direct route from Canacona to Mashem via Char Rasta, significantly reducing the travel distance from 21 kilometres to just 7 kilometres. Spanning a total length of 6.21 kilometres, the project includes the construction of three major bridges—Talpona, Galgibag, and Mashem—collectively measuring 1.5 kilometres, along with six underpasses to facilitate local transportation.[2] Developed at a cost of ₹294 crore, the Canacona Bypass represents a significant investment in regional infrastructure. The bypass was officially inaugurated on November 29, 2019, by the Hon'ble Chief Minister of Goa, Dr. Pramod Sawant, in the presence of Union Minister of State for Environment, Forest and Climate Change Shri Babul Supriyo, marking a key milestone in enhancing mobility in South Goa.[1]

**Results and Analysis:**

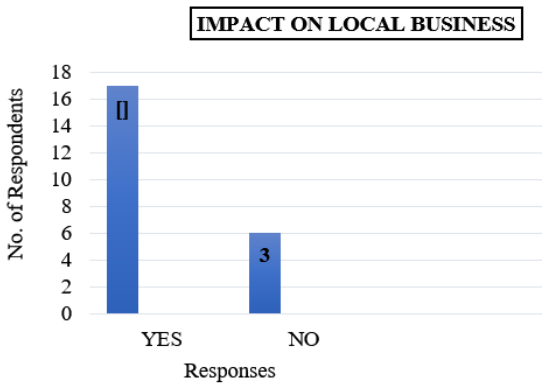
The findings reflect both the positive and negative experiences of people affected by the construction and ongoing presence of the bypass:-

**1. Loss of Property**

The issue of displacement emerged as a serious concern among respondents during the interview. Out of the 20 people surveyed, 7 reported that they had suffered direct damage or loss to their private property due to the construction of the Manohar Parrikar Bypass. These individuals stated that parts of their homes, shops, or agricultural land were either acquired or destroyed, forcing them to relocate or abandon portions of their living space. Some were displaced temporarily, while others lost their property permanently without adequate compensation or relocation support. The remaining 13 respondents stated that they were not affected in this regard, primarily because they did not own property within the project's footprint. Some of them claimed that they also lost their agricultural field. However, even among those not displaced physically, some shared that they felt psychologically displaced, as the project altered their neighbourhood, disrupted familiar surroundings, and severed social ties.

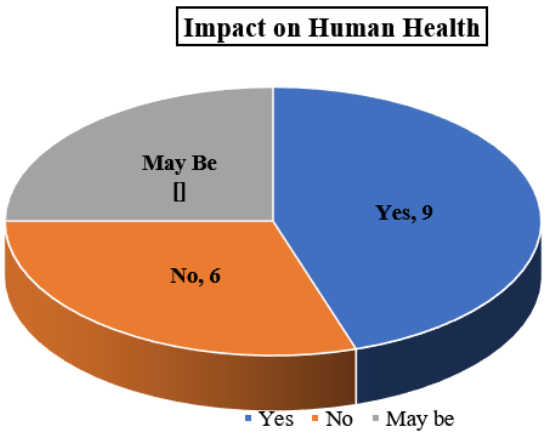
**2. Impact on local business**

The construction of the Manohar Parrikar Bypass has had a notable impact on local businesses in the area. The economic implications of the project were deeply felt by business owners and service providers in the area. A majority 17 out of 20 respondents stated that local businesses had been adversely affec ted. Some reported a decline in customer flow, temporary closure, or relocation due to roadblocks and construction noise. Only 3 people felt that local businesses remained unaffected, likely because their livelihood was not directly dependent on foot traffic or location-specific services.



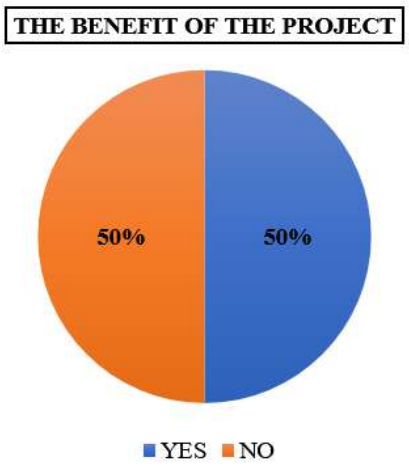

**3. Impact on Human Health**

Interactions with the residents revealed minor but concerning health issues, especially those related to respiratory problems. 9 people confirmed they had experienced breathing difficulties, attributing them to toxic gases and dust from increased vehicle movement near the construction site. Meanwhile, 6 individuals denied any health concerns, and 5 respondents, uncertain about the link, reflecting possible underreporting or unclear symptoms.



**4. Benefit from the Project**

When asked whether the project had personally benefited them, the responses were evenly split. 10 people said "Yes," believing the bypass improved transportation, access, and employment prospects. The other 10 responded with a firm "No," claiming the project had negatively impacted their lives through health concerns, environmental degradation, or loss of livelihood. This split in opinion illustrates the duality of infrastructure development; while it may facilitate progress for some, it can simultaneously displace or harm others.




**Conclusion**

The NH66 Manohar Parrikar Bypass has undeniably enhanced transportation and accessibility within the Canacona taluka, contributing to the broader developmental goals of the region. Infrastructure projects of this scale are essential for improving regional connectivity and easing daily commutes. However, such development must adopt a people-centric approach, ensuring that adverse effects on local communities; particularly in terms of displacement and livelihood disruption are minimized. While this study focuses on the socio-economic dimensions of the bypass, it also opens avenues for future research, particularly in examining the environmental impacts associated with the project.

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THE KONKAN GEOGRAPHER
Vol. No. 34, June/July 2025, ISSN No. 2277-4858
Impact Factor *(IIFS)* 8.125
(Interdisciplinary Peer Review Refereed Research Journal)

# Spatial Distribution of Transport Facilities of Urban Centers in Haveri District, Karnataka State

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**Research Paper Received on 10-05-2025 Edited & Accepted on 30-06-2025**

**Abstract:**

*The efficient distribution of transport facilities is crucial for urban development, connectivity and regional integration. This study analyzes the spatial distribution and accessibility of transport facilities in the urban centers of Haveri District, Karnataka. By evaluating various modes of transport such as road, rail, and public transit networks, the research identifies patterns, gaps, and inequalities in infrastructure allocation.*

*The study employs Geographic Information System (GIS) tools, field surveys, and statistical methods to map and assess the transport network's coverage and its impact on socio-economic development. Results reveal significant variations in transport facility density, with better connectivity in urban centers like Haveri and Ranebennur, while smaller towns face challenges due to limited infrastructure and accessibility.*

*The findings underscore the need for policy interventions to enhance equitable transport development, prioritize underserved areas and promote integrated urban-rural connectivity. This research contributes to understanding the relationship between transport infrastructure and regional development in emerging urban areas of Haveri district.*

**Key words:** transport, connectivity, integration, infrastructure and prioritize.

## Introduction:

Transport infrastructure plays a pivotal role in shaping the socio-economic and spatial structure of urban areas. It acts as a backbone for urban development by enhancing mobility, fostering economic growth and ensuring regional integration. The spatial distribution of transport facilities directly influences the accessibility, connectivity and overall development of 10 urban centers (2 CMC, 05 TMC and 03 TP) in the 08 talukas of Haveri district. In developing towns like Haveri District in Karnataka, understanding the spatial patterns of transport infrastructure is essential to address issues of inequality and inefficiency.

Haveri District, located in the heart of Karnataka, is characterized by a mix of urban and rural settlements with its urban centers serving as hubs for trade, education and administrative activities. However, the distribution of transport facilities across these centers is not uniform, leading to disparities in connectivity and development potential. Major towns like Haveri and Ranebennur are relatively well-connected, while smaller towns and peripheral areas like Byadgi. Hirekerur, Hanagal, Shiggaon - Savanur, Guttal and Bankapur often face challenges in accessibility.

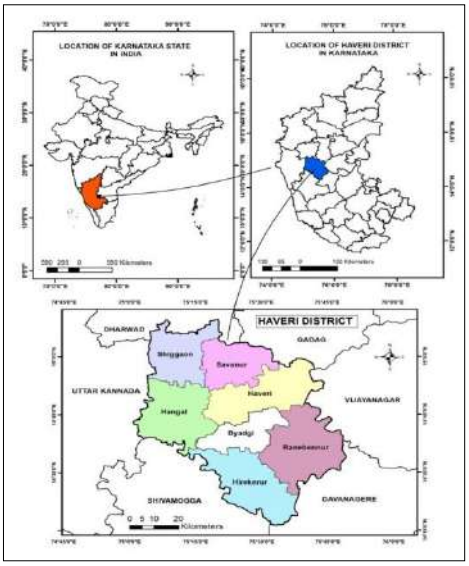
This study focuses on analyzing the spatial distribution of transport facilities in the urban centers of Haveri District. It examines the availability and connectivity of road and rail networks, the role of public transportation and the relationship between transport infrastructure and urban growth. Using Geographic Information System (GIS) tools, along with primary and secondary data, the study aims to highlight the existing patterns and identify gaps in transport accessibility.

The findings of this research are expected to provide insights into the spatial inequalities in transport infrastructure and inform policy interventions aimed at achieving balanced urban and regional development. By addressing the disparities in transport facilities, this study contributes to the broader goal of sustainable and inclusive growth in the urban centers.

**Study Area:**

Haveri district is located in the central part of Karnataka, India and is known for its rich cultural heritage, historical significance and diverse geography. The district spans an area of 4,823 square kilometers with total population of 1597668 (2011) and the density of the population is 331 persons per square kilometers. The Ranebbennur is being largest taluka in terms of area and Byadagi being the smallest one. As far as population is concerned, Ranebbennur taluka being highest one and Byadagi taluka has the lowest population.

The district is bound by Dharwad and Gadag Districts in the north, Davanagere and Shivmogga Districts in the south, Uttara Kannada district in the south west. and is situated between 14°17' and 15°04' North latitude and 75°01' and 75°50' East longitude.




**Area, Population and Administrative Status of Haveri District**

| Sl. No. | Talukas | Geographical Area (In Hectares) | Population | Towns | Hoblies |
|---|---|---|---|---|---|
| 1 | Byadgi | 43656 | 141024 | 1 | 2 |
| 2 | Hangal | 77525 | 260455 | 1 | 3 |
| 3 | Haveri | 79985 | 280362 | 2 | 3 |
| 4 | Hirekerur | 80694 | 231115 | 2 | 3 |
| 5 | Ranebennur | 90475 | 335281 | 1 | 3 |
| 6 | Savanur | 53901 | 161521 | 1 | 2 |
| 7 | Shiggaon | 58920 | 187910 | 2 | 3 |
| | **Total** | **485156** | **15,97,668** | **10** | **19** |

**Geographical Features:**

Haveri is part of the Deccan Plateau and exhibits typical features of this region, such as gently undulating terrain and black soil. The Tungabhadra River flows through the district border, Varda, Kumadvati, Dharma etc are contributing to its over-all development. The climate is semi-arid with distinct seasons of summer, monsoon and winter. Rainfall is moderate, averaging around 600-700 mm annually, and is primarily influenced by the southwest monsoon.

**Review of Literature:**

The review of literature on transport facilities in urban centers explores the relationship between urbanization, transport infrastructure and socio-economic development. Transport systems play a crucial role in shaping urban areas by influencing connectivity, accessibility and the distribution of resources. Below is a thematic synthesis of relevant studies.

Transport facilities are fundamental for the growth and sustainability of urban centers. Scholars like Rodrigue and Notteboom (2020) emphasize that well-developed transport systems contribute to economic productivity, social inclusion, and environmental sustainability. They highlight how efficient connectivity can reduce urban congestion and support regional trade. Litman (2019) underscores the importance of multimodal transport systems in promoting sustainable urban growth, particularly in mid-sized cities. The spatial distribution of transport facilities affects the accessibility of services and economic opportunities in urban centers. Studies by Banister (2008) and Schafer (2000) link public transport systems to reduced

environmental impacts and increased urban mobility. Central Place Theory, introduced by Christaller (1933), explains how transport facilities support hierarchical urban systems.

The gaps in the literature highlight the need for focused research on smaller and mid-sized urban centers, the use of modern spatial analysis tool and the integration of socio-economic and environmental considerations into transport planning. Addressing these gaps can lead to a more comprehensive understanding of transport facilities and their role in urban development, particularly in regions like Haveri district, Karnataka.

**Objectives:**

- The main objective of the study is to discuss the existing transport facilities of towns in the study area mainly confined
- To analyze the spatial distribution of transport facilities across urban centers using GIS techniques.
- To assess the accessibility and connectivity of transport facilities in urban centers.
- To evaluate the socio-economic impact of transport facilities on urban development
- To identify gaps and disparities in the distribution of transport facilities among different urban centers.
- To study the role of transport facilities in linking urban centers with their rural hinterlands.
- To recommend strategies for improving the spatial distribution and efficiency of transport facilities in urban centers of Haveri district.

**Database and methodology:**

Spatial Distribution of Transport Facilities in Urban Centers of Haveri District, Karnataka State. This section is outline the data sources, data types and methods employed in analyzing the spatial distribution of transport facilities in urban centers of Haveri district. Data from Karnataka State Transport Department and Haveri District Urban Development Authority and examine the relationship between transport infrastructure and factors like employment, trade and population movement. It ensures a systematic and scientific approach to the research.

**Selected Parameter:**

Research area is concern, there are seven parameter of transport has chosen to ascertain hierarchal by towns in the research area.

According to transportation perspective, people and materials can move around. The study region's transportation system is designed to take into account the geography of the area. The conduits that carry economic resources from areas of abundance to areas of scarcity are known as transportation lines. A region cannot be considered well developed if it lacks an efficient transportation system. It is common knowledge that the transportation network's linkages indicate the level of regional development and the priorities for investment in the region's future growth. Consequently, much transportation entity is takes in to examined, such as the Internal Roads, Sub Roads, Main Roads, State Highway Bypass, National Highway Bypass, Main Bus-stand and Railway Station. in ward level, assigned weights based on the road and rail systems' connectivity, and talked about the effectiveness in the research region.

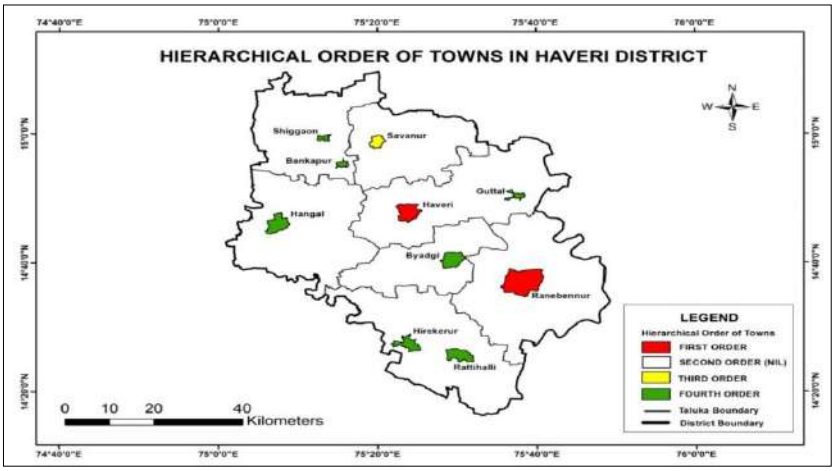
**Towns Weightage Schemes of Parameter**

| Facilities' | Weightages' |
|---|---|
| Internal Roads | 0.1 |
| Sub Roads | 0.2 |
| Main Roads | 0.3 |
| State Highway Bypass | 0.4 |
| National Highway Bypass | 0.5 |
| Main Bus-stand | 0.6 |
| Railway Station | 0.7 |

**Order-wise Town System in Haveri District'**

| Sl. No. | Name of the Towns | No. of Wards | Orders-wise Numbers of wards with Centrality Index (CI) | | | |
|---|---|---|---|---|---|---|
| | | | I (>90) | II (60-90) | III (30-60) | IV (<30) |
| 1 | Bankapur (TMC) | 23 | 00 | 00 | 00 | 1 |
| 2 | Byadgi (TMC) | 23 | 00 | 00 | 00 | 1 |
| 3 | Guttal (TP). | 18 | 00 | 00 | 00 | 1 |
| 4 | Hangal (TMC) | 23 | 00 | 00 | 00 | 1 |
| 5 | Haveri (CMC) | 31 | 1 | 00 | 00 | 00 |
| 6 | Hirekerur (TP) | 20 | 00 | 00 | 00 | 1 |
| 7 | Ranebennur (CMC) | 35 | 2 | 00 | 00 | 00 |
| 8 | Rattihalli (TP) | 11 | 00 | 00 | 00 | 1 |
| 9 | Savanur (TMC) | 27 | 00 | 00 | 00 | 1 |
| 10 | Shiggaon (TMC). | 23 | 00 | 00 | 1 | 00 |
| **District Total** | | **234** | **02** | **00** | **01** | **07** |

Source: Personal' Computation, 2023




**Analysis:**

To analyze the spatial distribution of transport facilities in urban centers of Haveri District, Karnataka, we can follow a systematic approach that incorporates both quantitative and qualitative methods. The analysis of the spatial distribution of transport facilities in Haveri District should provide insights into how well urban centers are connected which areas need improvement and how transport infrastructure impacts local mobility and economic growth. By combining mapping with accessibility analysis and transport data will be able to offer a comprehensive evaluation of the current transport situation and highlight areas for development.

**Spatial Distribution of Transport Facilities of Urban Centers:**

Any region's ability to develop quickly depends on its transportation system because without it, materials and labour would not be available. Transportation is like nerves system of a region it play an crucial part to development of the region, accordingly study area has good transportation facilities. There are various kinds of road networks are connected viz., Internal Roads, Sub Roads, Main Road, State Highway Bypass, National Highway Bypass, Bus-Stand and Railways.

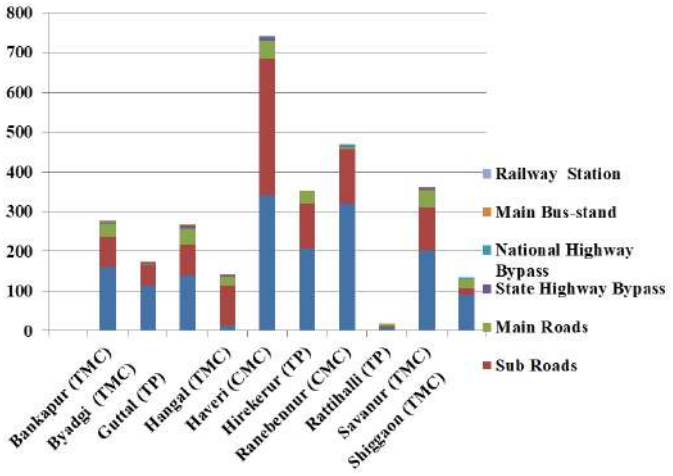
## Transport Facilities in Towns of Haveri District

| Sl. No. | Name of the Towns | No. of Wards | Internal Roads (In Km) | | | Sub Roads (In Km) | | | Main Roads (In Km) | | | State Highway Bypass (In Km) | | | National Highway Bypass (In Km) | | | Main Bus-stand | | | Railway Station | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total No. of | No. of Wards having | No. of Wards not having | Total No. of | No. of Wards having | No. of Wards not having | Total No. of | No. of Wards having | No. of Wards not having | Total No. of | No. of Wards having | No. of Wards not having | Total No. of | No. of Wards having | No. of Wards not having | Total No. of | No. of Wards having | No. of Wards not having | Total No. of | No. of Wards having | No. of Wards not having |
| 1 | Bankapur (TMC) | 23 | 159 | 23 | 00 | 76 | 23 | 00 | 35 | 23 | 00 | 02 | 02 | 21 | 04 | 04 | 19 | 01 | 01 | 22 | 00 | 00 | 23 |
| 2 | Byadgi (TMC) | 23 | 114 | 23 | 00 | 50 | 23 | 00 | 02 | 02 | 21 | 06 | 06 | 17 | 00 | 00 | 23 | 01 | 01 | 22 | 00 | 00 | 23 |
| 3 | Guttal (TP) | 18 | 139 | 18 | 00 | 77 | 18 | 00 | 40 | 16 | 02 | 09 | 08 | 10 | 00 | 00 | 18 | 01 | 01 | 17 | 00 | 00 | 18 |
| 4 | Hangal (TMC) | 23 | 15 | 13 | 10 | 99 | 22 | 01 | 22 | 22 | 01 | 05 | 05 | 18 | 00 | 00 | 23 | 01 | 01 | 22 | 00 | 00 | 23 |
| 5 | Haveri (CMC) | 31 | 341 | 31 | 00 | 344 | 31 | 00 | 43 | 22 | 09 | 09 | 09 | 24 | 02 | 02 | 29 | 01 | 01 | 30 | 01 | 01 | 30 |
| 6 | Hirekerur (TP) | 20 | 207 | 20 | 00 | 114 | 20 | 00 | 31 | 20 | 00 | 00 | 00 | 20 | 00 | 00 | 20 | 00 | 00 | 20 | 00 | 00 | 20 |
| 7 | Ranebennur (CMC) | 35 | 319 | 35 | 00 | 139 | 35 | 00 | 04 | 08 | 27 | 01 | 01 | 34 | 04 | 04 | 31 | 01 | 01 | 34 | 00 | 01 | 34 |
| 8 | Rattihalli (TP) | 11 | 09 | 07 | 04 | 03 | 02 | 09 | 04 | 04 | 07 | 00 | 00 | 00 | 00 | 00 | 00 | 01 | 01 | 10 | 00 | 00 | 11 |
| 9 | Savanur (TMC) | 27 | 201 | 27 | 00 | 109 | 27 | 00 | 44 | 27 | 00 | 05 | 05 | 22 | 00 | 00 | 27 | 01 | 01 | 26 | 00 | 00 | 27 |
| 10 | Shiggaon (TMC) | 23 | 90 | 23 | 00 | 18 | 10 | 13 | 23 | 17 | 06 | 00 | 00 | 23 | 04 | 04 | 19 | 00 | 00 | 23 | 00 | 00 | 23 |
| | Total | 234 | 1594 | 220 | 14 | 1029 | 211 | 23 | 248 | 161 | 73 | 37 | 36 | 189 | 14 | 14 | 209 | 08 | 08 | 226 | 01 | 02 | 233 |

Source: Town Panchayath of Haveri District and Personal Computation, 2023.

As far as Internal Roads are concerned, there are the basic transport connectivity system in the interior part of the either a town or district with a length of 1594 Kilometers followed by 1029 kilometers of Sub Roads still 23 Wards do not have this kind of roads of the 248 kilometers of Main Road and State Highways Bypass are passing through in the district with of 37 kilometers. There are National Highways bypass are passing in the Bankapur (TMC), Haveri (CMC), Ranebennur (CMC) and Shiggaon (TMC) with of 14 kilometers length in this study. Each and every town has a Bus stand facilities. As per as railway station is concerned, Haveri (TP) Byadgi (TMC) and Ranebennur (CMC) are having has alone with a Railway station the study area. There 03 railway stations are found in the study area but those are not comes under the Towns jurisdiction.

**Transport Facilities in Towns of Haveri District**
**(Roads in Kilometers and Bus-Stand & Railway Station in Numbers)**



**Conclusion and Planning Strategy:**

In view of this above the discussion with the evidences have been proved the hypothesis that, the socio-economic facilities are not only out come from the physical but also the infrastructure facilities of towns has been confirmed.

The analysis of the spatial distribution of transport facilities in the urban centers of Haveri District reveals several key insights regarding the accessibility, connectivity, and efficiency of the transport infrastructure. Based on the study, the following **conclusions** can be drawn:

The spatial distribution of transport facilities across urban centers in Haveri District is uneven. While major towns like Haveri, Ranebennur and Shiggaon are better connected with well-developed road networks, bus services, and proximity to major highways, smaller urban centers and peripheral towns often lack adequate transport infrastructure. This disparity results in limited mobility options for residents of rural or semi-urban areas.

Public transport coverage, primarily in the form of bus services is concentrated in major urban areas. Smaller towns and villages are underserved leading to a high dependency on private transport, which exacerbates traffic congestion and increases transportation costs for residents in less connected areas. While the road network density in urban centers is adequate, rural areas often face road quality issues, with a high proportion of unpaved or poorly maintained roads. This affects the reliability and safety of transportation, especially during monsoons or peak traffic periods.

The spatial distribution of transport facilities has a significant impact on economic development. Areas with better transport access tend to experience higher economic activity, with better access to markets, employment, and essential services. However, areas with poor connectivity face barriers to growth and development, making them vulnerable to economic stagnation.

To improve the spatial distribution of transport facilities and ensure equitable access for all urban centers in Haveri District, the following **planning strategy** is proposed.

Extend bus routes to cover underserved urban centers and rural areas, focusing on areas that are currently isolated or poorly connected to main towns.

Introduce more frequent services during peak hours and ensure that fares are affordable for the general population. Consider introducing feeder buses to link outlying areas with larger transport hubs like railway stations.

Enhance connectivity between bus and railway services by creating well-designed transport hubs where passengers can easily transfer between different modes of transport. Establish coordinated schedules for buses and trains to reduce wait times.

Upgrade key transport hubs, such as bus terminals and railway stations, to accommodate growing traffic volumes. These hubs should include amenities like parking spaces, waiting areas, food courts, and access to real-time travel information.

The spatial distribution of transport facilities in Haveri District reflects significant disparities in connectivity and accessibility between urban and rural areas. To address these issues and promote inclusive economic growth, the proposed planning strategy focuses on expanding and improving the public transport network, upgrading road infrastructure, enhancing intermodal connectivity and promoting sustainable transport solutions. A forward-looking approach that integrates technology and ensures inclusivity will contribute to building a robust and resilient transport system in Haveri District. Providing better access and mobility for all residents.

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THE KONKAN GEOGRAPHER
Vol. No. 34, June/July 2025, ISSN No. 2277-4858
Impact Factor *(IIFS)* 8.125
(Interdisciplinary Peer Review Refereed Research Journal)

# Ethnic Identity Crisis in North-East India: Special Emphasis on Intra-Ethnic Conflict in Assam

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**Research Paper Received on 30-05-2025 Edited & Accepted on 22-07-2025**

***Abstract***

*The North- East India is not a homogeneous unit as it comprises numerous ethnic groups as tribes and non tribes with distinct identities and different problems. It seems that Indian state has never tried to understand the heterogeneity of the region, but has been trying to impose on them as homogeneous groups with the main stream of culture. This imposition has been leading to different ethnic conflicts to protect and safeguard their ethnic identity under the constitution of India. The plain tribes of Assam like the Bodos, the Misings, the Rabhas, the Tiwas, the Deoris, the Sonowal Kacharis and the hill tribes of the Karbis and the Dimasas have been demanding different political power and other constitutional rights since independence which lead to intra-ethnic conflict in Assam. In this paper I have tried to analyze the problems of ethnic Identity conflict of North- East India as well as the Intra- ethnic conflict of Assam. In this seminar paper I have tried to study the causes and consequences of Ethnic identity crisis and its present trend of the intra Ethnic conflicts for their autonomy*

**Keywords:** Ethnic, Identity, Intra-ethnic, constitution, homogeneous, heterogeneous, etc.

**Introduction**:

The word 'Ethnic' derived from the Greek word 'Ethos' which means 'a tribe'. Ethnic groups exists by virtue of long standing association across generations complex relations of kinship common culture and religious uniformity and common territorial attachment.

North East India is constituted by eight states namely Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim. The North East India which is a very uncommon area in our country as well as in the world. Various ethnic groups lives in this region namely, Ahom, Mising, Bodo, Deori, Nacte, Tangcha, Mizu, Khasi, Luthus, Maithi, Tripuri, Kanyak, Angami, Aou Naga, Sema Naga etc. Therefore some social thinkers like to say that the North-East India as India in miniature in terms of ethno-cultural diversities. It may be mentioned here that as many as 209 ethnic groups of this region are recognized as scheduled tribe. Out of those tribes 101 are in Arunachal Pradesh, 23 in Manipur and 14 in Tripura. Ethnic Identity crisis and intra-ethnic conflict become a very relevant issue of discussion in the present situation of North East India.

In Assam different tribes such as the Bodos, the Misings, the Rabhas, the Tiwas, the Sonowal Kacharis of plain tribes and the Karbis and the Dimasa Kachari of hill tribes have been demanding autonomy in their respective dominated areas under Six Schedule of the constitution of India to meet their rapid collective development. Of course, the Bodos of plain tribe and hill tribes of Dimasa Kacharis and Karbis have achieved their minimum political goal. It is because the tribes of Assam are socio-economically very backward than the non-tribal groups and each of them has own dialect, language, culture, religion, customs, tradition etc. They have been dominated by non-tribal groups since ages. In the age globalization and the impact of modern education, many ethnic groups either tribal or non tribal have almost lost their own socio-cultural identity. Hence the identity crisis has been suffered by them and the responsibility of preserving their identity is being taken by some elites of the respective tribal groups through various ethnic movements. The Mising of Assam has also been continuing their autonomy demand since one and half decade to go ahead with other advanced tribes and the non-tribes of Assam and other regions of North East India.

**Aims and objectives**:

The main objectives of this study are-

1. To know the origin and causes of ethnic conflict in Assam.
2. To observed the crisis of ethnic identity in North-East India as well as Assam.
3. To know the intra- ethnic conflict in Assam, etc.

**Methodology:**

The study is based on general information. The paper is mainly based on secondary sources of data. The relevant secondary data have been collected from the books, journals, newspaper, research paper, internet, etc.

**Result and Discussion:**

The intra-ethnic conflict among the tribal is a common 0phenomenon in the present century. The north-east society is a mosaic of ethnic groups. Many groups or community used to consider themselves as integral part of grater community. This led identity crisis among smaller groups. In Nagaland, the people of Naga identified themselves as having different ethnic groups in consideration with sure name as Ao Naga, Sema mobilized by NSCN (IM) group on one hand. The Tangkul Naga, on the other mobilized by NSCN (K) groups. As a result they have been engaged in ethnic warfare among each other. In Mizoram, ethnic clash arises between the Lushai and others. In Tripura, it arises between tribal and non-tribal. Meghalaya also witnessed the same type of ethnic conflict that prevails in others.

**Ethnic conflict in Assam:**

**1. Bodo Vs Assamese middle class:**

The Bodo constitute an integral part of Assamese mainstream. They have distinct ethnic identity of their own. However, the scenario began to change from 1950 onwards. With the formation of the 'Bodo Sahitya Sabha,' the Bodo educated elite resisted the Assamese hegemony. The movement for Bodo script (1947) and language indicated their ethnic consciousness and political aspiration. Their agitation was directed mainly against Assamese middle class and the big brotherly attitude of the Assamese nationality. The formation of 'Bodo Autonomous Council'(BAC) did not satisfy the political aspirations of the Bodo elite and thus resulted in a movement. The creation of a separate state of a Bodoland, dividing Assam fifty fifty, etc. were the principal demand of the Bodo's. When the Assam accord provided important safeguards for the identity of the people of Assam. The clause 'C' of the Assam accord said, 'Constitutional, legislative and Administrative safeguards, as may be appropriate, shall be provide to protect, preserve and promote, the cultural, social and linguistic identity and heritage of the Assamese people.

The leaders of the Bodo movement were specially attracted by this clause. They were interested to achieve similar, constitutional, legislative and administrative safeguards for the Bodo people. The Bodo movement was led by the students (ABSU). The ABSU was formed in 1967 and came into prominence in 1986. In order to pursue their interest, they started mobilizing the lower strata of their own community. In 1988, the 'Bodo Peoples Action Committee' was formed to mobilize all the people of the Bodoland movement. The 'BPAC' can be considered as the armed using of the 'ABSU'. Violence was commited against the non-tribes of the district of Dhubri, Kokrajar, Barpeta, Nalbari, Darrang and Sonitpur.

In 20th February,1993 Bodo Accord was formed among ABSU, BPAC, Central government and State government. According to this accord there will be 'Bodo Territorial Council' with 50% Bodo inhabited areas. Creation of Bodoland Territorial Council in the 'BTAD' districts which included district of Kokrajar, Chirang, Udalguri and Baksa. Now, Bodo's have formed a new political party name " The Bodoland Peoples Prograssive Front" (BPPF) and The United People's Party Liberal (UPPL).

Though BTC has been working till 2003 according to the new Bodo accord 13th February, 2003.Third Bodo Accord was signed in 2020, it renamed the BTAD as Bodoland Territorial Region (BTR). It promises more legislative, executive and administrative autonomy under the sixth schedule to Bodoland Territorial Council (BTC) and expansion of the BTC territory in lieu of statehood. But they have faced various

challenges. Firstly, in BTR areas Bodo people are seen minority. In some areas only 25% Bodo people ruled over 75% non- Bodo people. Another challenge is emerge of insurgent group. In BTR areas one extremist group called "National Democratic Front of Bodoland" always demanding independent and sovereign state for Bodo's. So, now it is time to see how govt. tries to satisfy these communities and solve their problems.

**2. Hamar Vs Dimasa**:

In North Cachar Hills (NCH) of Assam there was an ethnic clash between Hamars and Dimasas in 2003. The growth of this has firstly appeared to be communal politics. Dimasa vs Non- Dimasas had been rooted back to 19, when Dimasa had voice their slogan that 90% reservation, Cachar for Kachari, N.C.Hills for Dimasa. The Hamars are believed to be tribe among others by virtue of being economically more developed proportionate to their population in comparison with others. This created covetousness to the other.

In the first part of 2003, the long standing aspiration of the DHD had been passed by the majority of the members in council renaming the existing " N C Hills Autonomous Council" into Dima-Halili meaning council of Dimasa, consequently, the eminent leaders of the Non-Dimasa like D. Thuoma Hamar, I Jeme, V. Changsan and other submitted a memorandum to the governor of Assam on the issue.

However, on 26 February 2003, at Dittokcherra area, the militant group belonging to NSCN (IM) headed by Darasing Zeme kidnapped three DHD militant. Taking advantage of this to be a golden chance for exploiting their envious of the Hamars knowingly the DHD pretended it was to be the conspiracy of the Hamar people on that kidnapping and on March 2, 2003 ferociously they harassed and tortured the Hamar people of neighboring Hamar villages of Dittokcherra and Harangajuo and kidnapped three persons, who were traceless till date. Besides N C Hill, the Hamar villages like Tuitha, Baroidisa, Mouldam were also harassed.

With the burning like a fire wells of some of the Hamar Youth took revenge by attacking Chekercham village of Barman community known as Dimasa of Cachar district and later it had broke out into fall ethnic clash between the two communities.

**3. Karbi Vs Kuki**:

However the issue often arises with the season for selling off their crops comes as the extremist group "United Peoples Democratic Solidarity" (UPDS) who belong to the Karbi community heavy taxes on transportation of commodities by Kuki cultivators. In it turns when the Kuki reluctant to pay taxes, ethnic clash arises between the two groups.

In Non compliance with payment of takes by the Kuki farmers, the " UPADS" had undertook armed action against the reluctant group of people and in it turned the "Kuki Revolutionary Army" (KRA), as extremist group belong to Kuki community. Thus the action and canter action Smeared the entire population of both communities happened to involve that had turned into commune clash basedon ethnic group headed by extremist from each group.

**4. Karbi Vs Dimasa**:

There have been ideological differences between Karbi and Dimasa community. The demand made by the DHE for separate state demarcating the areas apart from N C Hills, it covers some part of Dimapur, presently in Nagaland and some parts of Diphu, presently in Karbi- Anglong. At the same time, the designated camp established by DHE in Karbi- Anglong was also a sentimental and humiliation on the part of UPDS (United Peoples Democratic Solidarity) and Karbi people.

Apart from the above mentioned intra-ethnic conflicts some other ethnic clash arises in Assam between various ethnic groups. On 1996 the Bodo- Adivasi ethnic conflict took place where the Bodo militant group has actively engaged. Ultimately thousands of Adivasi people have lost their life and wounded. This was one of the tragic incidents of contemporary Assam. Communal clash had around in 2006 based on ethnicity. In 2014 once again the Bodo militants have killed hundreds of Adivasi people which once again lead to Bodo-adivasi ethnic conflict.

**Conclusion:**

The problem of ethnicity has disturbed the whole social and political atmosphere of North-East India. The need of the hour is therefore, Co-ordinate development of all ethnic groups and a political will to establish peace in the minds of the indigenous population. As the ethnic problem is psychological, psycho-emotional approached is necessary for its solution. Care and understanding of the ethnic aspiration, through honest and sincere negotiation alone can establish unity among different ethnic groups. The demands of different ethnic groups should be viewed as a whole we must think in terms of development of the whole region. Political parties must enthuse the people in the spirit of unity. There also the intellectuals, Administrators, Media can contribute a great deal in creating congenial atmosphere.

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THE KONKAN GEOGRAPHER
Vol. No. 34, June/July 2025, ISSN No. 2277-4858
Impact Factor *(IIFS)* 8.125
(Interdisciplinary Peer Review Refereed Research Journal)

# The Evolution and Enhancement of Rural Life in the Villages of the Palkhi Marg in Maharashtra : An Exhaustive Geographical and Socio-Cultural Study

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**Research Paper Received on 01-06-2025 Edited & Accepted on 25-07-2025**

***Abstract:***

*The Palkhi Marg, which is in the Maharashtra state, is an historic and culturally important pilgrimage path that is meaningful to numerous individuals, especially in the context of the annual Wari tradition. Millions of devout pilgrims, referred to as warkaris, travel in this season from various points all over the state, many of whom start their pilgrimage in the major towns of Alandi and Dehu and move on to the holy pilgrimage site of Pandharpur. This sacred path, though most importantly spiritual in nature, passes through many rural villages that get a unique and impressive form of socio-economic and infrastructural growth. This constructive change is a direct consequence of the villages' location along the pilgrimage path, which shows the interdependence of spirituality and local development.*

*This study analyzes the developmental trajectory of villages situated on the Palkhi Marg in the context of infrastructural development, socio-cultural development, economic diversification, and environmental sustainability. The Wari tradition indirectly affects rural transformation through the roles of the government, NGOs, and people's participation for improving basic amenities to the pilgrim inflow.*

*The study utilizes primary data, which have been gathered carefully through different methods, including field surveys, extensive interviews, and intensive observation methods carried out in well-chosen villages along the Palkhi path. Apart from this primary data, the study is supplemented and reinforced using secondary data from different census reports, government reports, and corroborative research documents, which offer further depth and background to the findings. Major observations validate that villages along the pilgrimage route have seen enhanced connectivity through roads, better sanitation facilities, temporary health camps, and small businesses during the Wari season. Further, the cultural pride of hosting pilgrims has encouraged local communities to take up social work, cleanliness drives, and conservation of cultural heritage.*

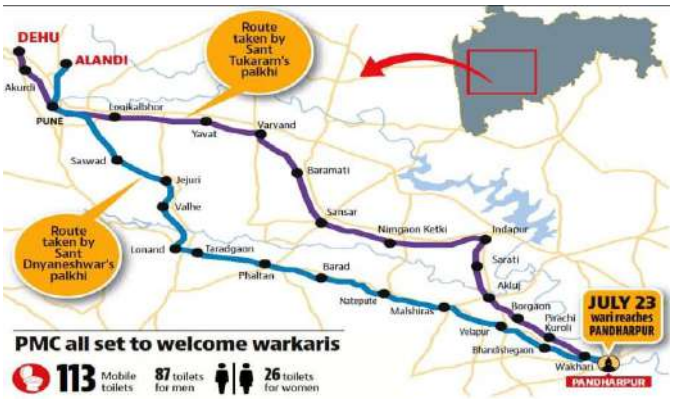
*However, it is worth mentioning that the growth is seasonal and transitory in nature, which leads to an inability to create sustainable economic transformation or provide real employment opportunities to the youth residing in rural areas. Along with this, the development of infrastructure tends to overlook the need for long-term planning, which eventually leads to environmental degradation as well as over-exploitation of natural resources.*

*This article concludes that while the Palkhi Marg is a driver for rural development, holistic and sustainable planning is required to convert the transient gains into long-term rural prosperity. The recommendations are the convergence of pilgrimage tourism with rural development schemes, capacity building programs for rural villagers, and environmental measures to sustain the rural landscape along the Palkhi Marg.*

## Introduction:

The Wari pilgrimage is among the most colorful and historically important cultural processions that India has to offer. Half a million devout pilgrims embark on a phenomenal journey on foot from the towns of Alandi and Dehu, all the way to the holy town of Pandharpur, in the state of Maharashtra, annually, to pay their homage to Lord Vitthal. The path that is walked by these devoted pilgrims, also known as the Palkhi Marg, is not just a religious pilgrimage for spiritual satisfaction, but it also ranks as an important socio-cultural channel that links hundreds of rural villages along its path.

Traditionally, Wari tradition started in the 13th century with the saint Dnyaneshwar and then with Tukaram Maharaj. Their Palkhis (palanquins) are taken along several rural spans, along with devotion, music, community service, and most significantly, interaction with villagers.




**Sant Dnyaneshwar Maharaj and Sant Tukaram Maharaj palakhi Marg. Alandi To Pandharpur, Dehu To Pandharpur**

**Importance and Relevance of the Study**

This religious-cultural phenomenon has a concrete effect on villages along its path. Better roads, seasonal jobs, and social interaction are typical. There is, however, very little scholarly work that systematically examines the multifaceted implications of the Palkhi Marg in rural society.

Comprehension and value of such impacts are of utmost importance in formulating and planning efficient rural development policies. Through such comprehension, equitable sharing of the gains among the host villages will be guaranteed. Second, it helps in safeguarding the integrity and viability of the highly prized Wari tradition.

**Field of Study:**

The Palkhi Marg is an important pilgrimage path that traverses a number of major districts such as Pune, Solapur, and Satara. There are important villages such as Pune,Saswad, Jejuri, Baramati, Indapur,Malshiras, Wakhari, and Pandharpur along the path, and each of them contributes importantly to the entire pilgrimage process. The degree of development of these villages can be seen to vary significantly, depending on whether they are located near or far from the Palkhi Marg and how effectively they deal with and absorb the movement of pilgrims along it.


**Objectives:**

1. To conduct an in-depth study of socio-economic development that has been taking place in villages along the Palkhi Marg.
2. To thoroughly investigate and study the various infrastructural changes that have been largely impacted by the annual festival known as Wari.
3. To identify how religious tourism has an important role to play in shaping and influencing the different aspects of rural lives and communities.
4. To determine the sustainability and long-term effects of such development.
5. To provide well-considered recommendations for the formulation of integrated rural strategies that would be practically implementable along religiously important corridors.

**Hypothesis:**

1. The annual Wari pilgrimage itself acts as a rural development agent for villages along the Palkhi Marg.
2. The advantages of pilgrimage-driven development are out of proportion and predominantly seasonal.
3. Proper planning and policy backup can make the Palkhi Marg a model for rural development in terms of development based on cultural tourism.

**Methodology:**

- **Primary Data Collection:**
  Systematic interviews of villagers, panchayat members, shopkeepers, and pilgrims.
  Field observation in Wari times.Photo and mapping of infrastructural development.
- **Secondary Data:**
  Census of India Reports (2001, 2011).Government Rural Development Schemes Reports. Academic journals, research papers, and news articles.
- **Sampling:**
  8 randomly chosen villages from Pune to Pandharpur. Stratified sampling was used to make sure that the selection process included villages of different capacities and sizes.

**Data Analysis and Findings:**

**Table 1: Basic Amenities in Sampled Villages Along Palkhi Marg**

| Village | Road Quality | Sanitation | Health Facilities | Accommodation | Internet Access |
|---|---|---|---|---|---|
| Pune | Good | Good | Hospitals / camp | Schools used | Yes |
| Saswad | Good | Moderate | Temporary camps | Guesthouses | Yes |
| Baramati | Excellent | Good | PHC + camps | Hotels | Yes |
| Indapur | Good | Moderate | Temporary camps | School colleges used | Yes |
| Lonand | Good | Good | Camp | School used | Yes |
| Natepute | Moderate | Poor | Camps only | Schools used | No |
| Wakhari | Poor | Poor | NGO-based | Houses shared | No |

**Key Observations**

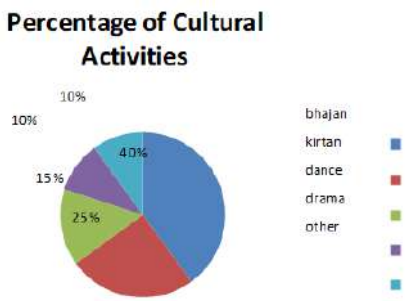
- Enhancement of roads and street lighting is a priority during Wari season.
- Sanitation changes are mostly temporary.
- Medical facilities are still underdeveloped aside from temporary medical camps.
- Variable accommodation is often used, with schools, temples, or community halls often being utilized.

**Social Impact**

Rural communities play a vital role in preserving the intangible heritage of the Palakhi Marg. Local festivals, folk songs, and rituals performed by villagers during the Wari enrich the spiritual journey. Villages such as Alandi and Baramati host performances of Abhangs (devotional poems), showcasing their cultural heritage.

- Increased sense of pride among villagers.
- Volunteering is done by women and the youth.
- Cultural activities like kirtans and bhajans bring about social harmony.

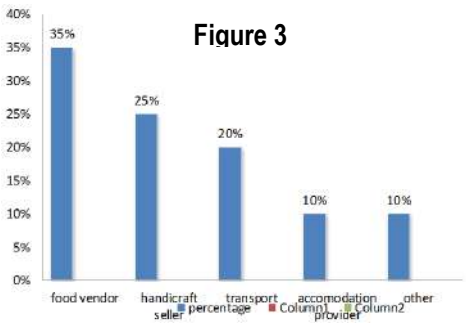
**Figure 2**




**Folk Arts Performed Along the Route**

This pie chart showing % distribution of types of cultural activi ties: Bhajans, Kirtans, Dance, Drama, etc.)

**Figure 3**




**Economic Impact -**

Economic Activity During Wari (based on survey)

•The local vendors, tea stalls, restaurants, and fruit sellers will receive a huge boost.

- Casual labor for transport, security, and cleaning.

• Lack of long-term income-generating activities.

This bar graph showing income increase across vendor categories

**Limitations of the Study:**

- The impact is mostly observed during the Wari season.
- Limited data on financial investment by the government.
- Seasonal nature of development restricts long-term analysis.
- Some villages were inaccessible during off-season due to poor roads.

**Recommendations:**

1. Permanent Infrastructure: Construct all-weather roads, toilets, and shelters for the pilgrims as well as for the villagers.
2. Developing skills: Train locals in hospitality, first aid, and tourism management.
3. Rural Tourism Circuits: Incorporate Palkhi Marg in eco-tourism and heritage circuits.
4. Funding Mechanisms: Encourage CSR participation and public-private partnerships.
5. Protection of the Environment: Firmly advocate for plastic-free campaigns and water conservation activities during the duration of the pilgrimage.

**Conclusion:**

The Palkhi Marg provides a very unique and distinct potential for blending the spaces of spirituality with the hard facts of sustainable rural development. The various villages on this important road experience a heightened level of activity and interaction, which manifests itself in short-term improvement in their infrastructure, all of which have the potential to yield high returns in the long term to the related communities. For the potential to be harnessed and maximized, however, it is important that there is a total shift from being seasonal in planning to a more stringent and systemic approach to planning development that considers the aspirations and needs of the locals.

Policymakers need to take notice and value the very crucial dual function that the Wari has, as a precious cultural heritage and a significant developmental force in society. By implementing the many accomplishments that had been achieved under the Wari period deliberately and by stretching the advantages that it has much beyond the pilgrimage season alone, the state and society can actually guarantee a balanced and sustainable development to these rural folk, enhancing their overall quality of life and progress.

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THE KONKAN GEOGRAPHER
Vol. No. 34, June/July 2025, ISSN No. 2277-4858
Impact Factor *(IIFS)* 8.125
(Interdisciplinary Peer Review Refereed Research Journal)

# Land Use and Land Cover Changes in Valpoi Town of Goa and its Implications Towards Sustainability

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**Research Paper Received on 12-07-2025 Edited & Accepted on 27-07-2025**

***Abstract:***

*The study examines Land Use and Land Cover (LULC) changes of a small administrative town in the state of Goa, India, namely Valpoi during the period of a decade from 2013 to 2023, using Remote Sensing (RS) and Geographic Information System (GIS). High-resolution satellite imagery from Google Earth Pro was used to classify the studied urban area's landscape into eight major classes, revealing a slight decline in vegetation and an increase in settlements. These changes reflect the impact of growing urbanization in this eco-sensitive region near the Western Ghats. The study recorded high classification accuracy of 96.27 percent in 2013 and 97.57 percent in 2023. The findings underscore the need for sustainable land-use planning to strike a balance between development and environmental conservation. The recommendations are stricter zoning policies and community involvement to preserve the small town's ecological and cultural significance.*

**Keywords:** Land use and Land Cover, Urbanization, Eco-sensitive, sustainability.

## Introduction:

Land Use and Land Cover (LULC) analysis plays an important role in understanding the dynamic relationship that exists between human activities and natural processes. The LULC of all categories of towns is witnessing continuous changes due to urbanization, industrialization and modernization. The modifications not only impact the local environment but also influence socio-economic development, resource management and planning strategies. The land use planning, monitoring and evaluation of environmental degradation and managing climate change depend on Land Use and Land Cover maps (GN Vivekananda, R Swath, & AVLN, 2021). The present study analyses the LULC changes in Valpoi town using geospatial techniques and assess the transformations of various land classes such as built-up, vegetation cover, agriculture, water bodies, which provides a detailed pattern and drivers of land change in the semi-urban landscape.

## Urbanization and Land Use Land Cover

Urbanization is one of the dynamic and serious issues at present because rapid urbanization results the haphazard and unplanned growth of cities. The pressure of an ever growing population becomes a burden on the limited public facilities which are virtually collapsing; there is the need to balance present requirements of land with available facilities while considering future needs. Urbanization is a process through which the productive agricultural land, forests and surface water bodies are being irretrievably decreasing. Rapid growth of cities has posed a threat to their Central Business District (CBD). This is evident from the growing eagerness of the people to seek accommodation in rural-urban fringe areas (Tali, 2012).

Land use and land cover change (LU/LC) has been recognized as an important force of environmental change on all spatial and temporal scales (Turner, 1994). Monitoring land-use changes is essential for local and regional level planning studies in order to assess urban growth trends. The planning studies should be based on accurate and up to-date land use and Urbanization is one of the dynamic and serious issues at present because rapid urbanization results the haphazard and unplanned growth of cities. The pressure of an ever growing population becomes a burden on the limited public facilities which are virtually collapsing; there is the need to balance present requirements of land with available facilities while considering future needs. Urbanization is a process through which the productive agricultural land, forests and surface water bodies are being irretrievably decreasing. Rapid growth of cities has posed a threat to their Central Business District (CBD). This is evident from the growing eagerness of the people to seek accommodation in rural-urban fringe areas (Tali, 2012).

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**Study Area:**

Valpoi is a small and heritage town situated near the foothills of the Western Ghats covered with dense forest cover in Sattari taluka of Goa. Geographically, it extends from 15°33'3.61"N to 15°30'28.56"N latitude and 74°7'2.77"E to 74°9'34.91"E longitude. The term Valpoi is derived from two words, "Val" which means river, and "Poi" which signifies the other side (Census of India,1961). "Valpoi" is a town located on the other side of the river, primarily the Mhadei River and more commonly recognized as the Mandovi River. The Valpoi is an administrative town of Sattari taluka covering a total area of 11.95 square kilometers. The town has a total population of 8,532 (Census of India, 2011), constituting about 0.58 percent of the total population of the state. This region experiences an annual rainfall of approximately 108.39 millimetres. The town is a socio-economic hub, acting as a central location for commercial, medical and administrative activities of the administrative sub-region.

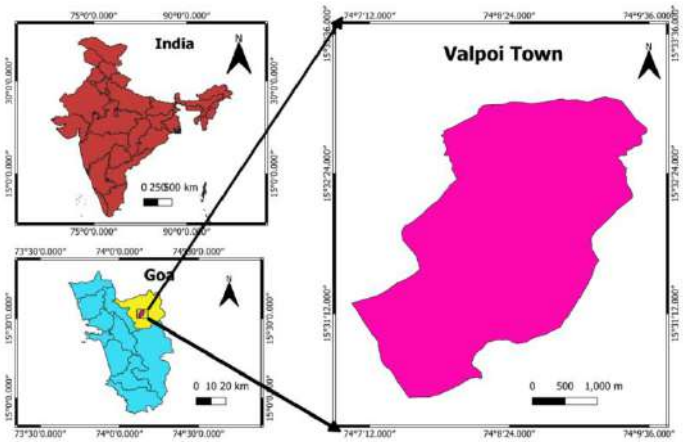


***Figure 1****:* Location Map of Valpoi Town in Goa in the context of Sattari Taluka of Goa.
*Source: Prepared by the authors using QGIS based on SoI and TCP, Govt. of Goa*

**Database and Methodology**

The study has used high-resolution satellite imagery from Google Earth Pro for 2013 and 2023, supplemented by Census of India data, regional maps from the Town and Country Planning Department of Goa. Additionally, various websites, journals and books were referred during the analysis. The study has used geospatial techniques for the assessment of Land use and land cover changes of Valpoi town using satellite imagery. For the Delineation of the Study Area, the regional map of the town was downloaded from the Towns and Country Planning department of Goa's Website. Later, it was georeferenced and manually digitized using QGIS software to define the study area.

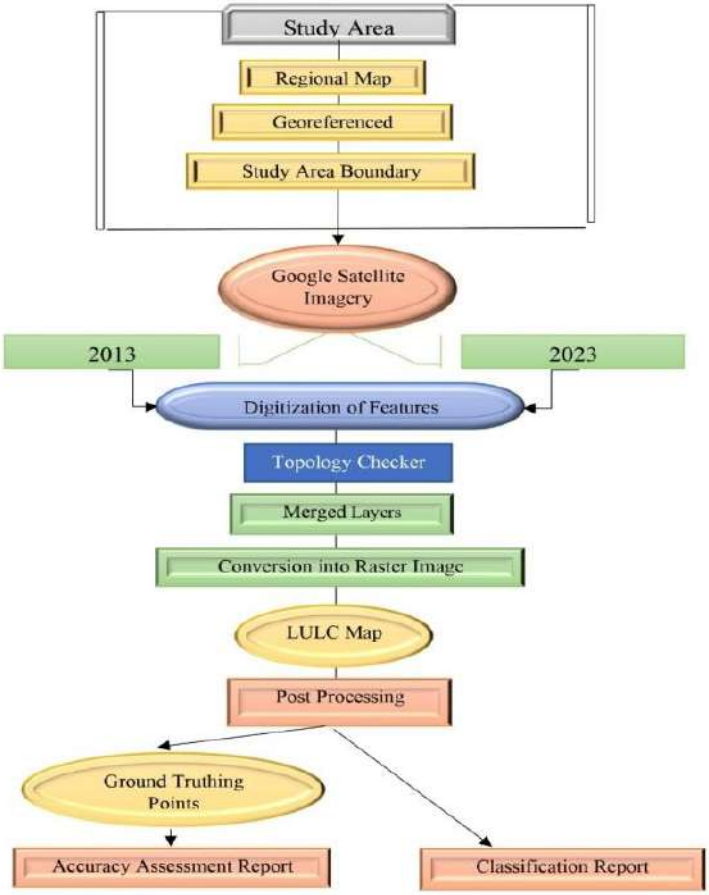


**Figure 2:** Methodology Applied for Land Use and Land Cover, 2013 & 2023.

**LULC Classification:**

LULC classification is an important GIS-based technique for extracting information from satellite imagery (Srivastava et al., 2012). Among the various techniques used for deriving LULC classification, supervised and unsupervised methods are the most widely used (Lang et al., 2008). The land use and land cover features were manually digitized for both the years of study using QGIS software version 3.32 Lima. The categories include Forest cover, Grassland, Water bodies, Plantation, Barren land, Built-up area, Agriculture land, and Road network, based on the NRSC Level 1 classification scheme.

**Accuracy Assessment**

Accuracy Assessment is a post-classification technique of LULC used to determine the precision of classified maps (Manandhar, Odeh, & Acnev, 2009). The accuracy assessment focuses on the error matrix, which computes overall accuracy and the Kappa coefficient (KC) value. The producer accuracy above 80 percent is highly reliable and respectively, KC values greater than 0.80 reveal a high degree of reliability on the classification (Rash, Mustafa, & Hamad, 2023). Although Google satellite imagery gives high resolution, the classification was further verified by ground validation through ground truthing of 50 points of each feature.

**Results and Discussion :**

The land use and land cover have been performed using Google satellite data for two decadal points, i.e., 2013 and 2023. The study has adopted the standard 8-ways classification of the National Remote Sensing Centre, India, 2011.

**Land Use and Land Cover of Valpoi Town, 2013**

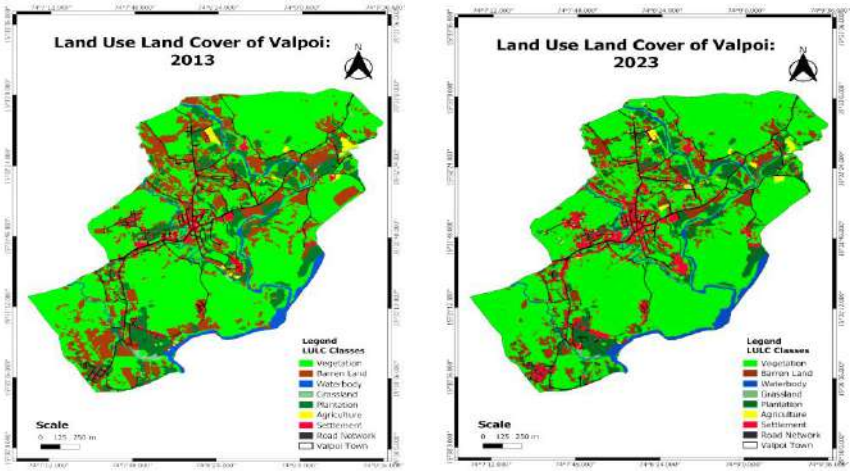


**Figure 3 A & B:** LULC Maps of Valpoi Town, 2013 and 2023.

Valpoi town has a lush green landscape covering different land uses and land covers. The study offers an insight into the patterns and types of land use during 2013. The major types emerged from the study are vegetation, settlement, barren land, agricultural lands, plantations, grassland, road networks and water bodies. These categories have played significant roles in shaping the socio-economic activities of the people in the town.

There are notable changes in land transformation over a decade in Valpoi town from 2013 to and 2023 (Table 1). In 2013, the Vegetation covered 8.01 sq. km area comprising 67 percent of the total town area (11.95 sq. km). By 2023, the Vegetation cover slightly decreased to 7.88 sq km (65.96%), though it maintained the dominant status among the categories of classification. Barren land decreased from 1.7 sq. km (14.21%) in 2013 to 0.35 sq. km (11.65%) in 2023. The area under water bodies increased slightly from 0.03 sq. km to 0.35 sq. km, due to seasonal river flow and resultant expansion. Plantation expanded from 0.99 sq. km (8.28%) in 2013 to 1.23 sq. km (10.33%) in 2023, mostly due to beautification measures by the Municipal Authorities and ongoing Social Forestry efforts. This is also due to an increase in coconut plantation and areca nut plantation for commercial purposes and self-consumption. Agricultural land showed only marginal growth, increasing from 0.06 sq. km to 0.07 sq. km, which indicates that less importance is given to traditional agriculture to expand. Settlement areas increased from 0.57 sq. km (4.77%) in 2013 to 0.69 sq. km (5.78%) in 2023, with most residential development concentrated in the town center and along the side of the roads. Grassland remains constant, covering just 0.03 sq. km in both the period of study years. The road network, which is essential for connecting Valpoi town with surrounding villages, expanded slightly from 0.29 sq. km (2.43%) in 2013 to 0.30 sq. km (2.49%) in 2023. The LULC maps for both years indicate that the HQ Town maintains a predominantly green landscape with steady but controlled urban expansion. The town with ecological richness and balanced land use highlights its role as a developing urban center within the eco-sensitive zone of Sattari taluka.

**Table 1: Showing LULC Classification Report for 2013 and 2023**

| Land Use Classes | 2013 Area (sq. km) | 2013 Area (%) | 2023 Area (sq. km) | 2023 Area (%) |
|---|---|---|---|---|
| Vegetation | 8.01 | 67.01 | 7.88 | 65.96 |
| Barren Land | 1.70 | 14.21 | 1.39 | 11.65 |
| Water Body | 0.30 | 2.47 | 0.35 | 2.92 |
| Grassland | 0.03 | 0.27 | 0.03 | 0.25 |
| Plantation | 0.99 | 8.28 | 1.23 | 10.33 |

| Land Use Classes | 2013 Area (sq. km) | 2013 Area (%) | 2023 Area (sq. km) | 2023 Area (%) |
|---|---|---|---|---|
| Agriculture | 0.06 | 0.53 | 0.07 | 0.62 |
| Settlement | 0.57 | 4.80 | 0.69 | 5.78 |
| Road Network | 0.29 | 2.43 | 0.30 | 2.49 |
| **Total** | **11.95** | **100** | **11.95** | **100** |

**Primary Matrix for Valpoi:**

The values of the land use and land cover as contained in Table 1 are consolidated into the Primary Matrix P (0) = 8.01, 1.7, 0.3, 0.03, 0.99, 0.06, 0.57, 0.29 for further analytical purposes and Accuracy Assessment of image classification for the study period 2013 and 2023. The accuracy assessment of the processed Land use/Land cover of the region is one of the most essential steps in image classification of any study area, which quantitatively assesses how effectively the pixels were sampled into the correct land use/land cover classes. To do the same, reference data is used to assess the accuracy of the image classification (Rwanga Sophia S., 2017). The theoretical confusion matrix (error matrix) of land use/Land cover classification of Valpoi town was carried out for 2013 and 2023 (Study points). The relationship between ground truth data and corresponding classified data have been obtained to calculate the error matrix report (Tables A.1 and A.2) using the established methodology (Foody, 2002) .

**Table 2: Accuracy Assessment of LULC for Valpoi Town, 2013 and 2023**

| Category | 2013 | | 2023 | |
|---|---|---|---|---|
| | User Accuracy (%) | Producer Accuracy (%) | User Accuracy (%) | Producer Accuracy (%) |
| Vegetation | 99 | 97.08 | 100 | 100 |
| Barren Land | 100 | 91.40 | 76.92 | 100 |
| Water body | 75.70 | 100 | 100 | 100 |
| Grassland | 100 | 100 | 100 | 71.43 |
| Plantation | 84.85 | 100 | 100 | 100 |
| Agriculture | 100 | 100 | 86.67 | 100 |
| Settlement | 100 | 88.24 | 100 | 57.14 |
| Road Network | 50 | 100 | 100 | 100 |
| Overall Accuracy (%) | **96.27** | | **97.57** | |

According to the land use/land cover classes, user's accuracy and producer's accuracy were calculated for the respective two-decade points of 2013 and 2023 for Valpoi town (Table 2). In 2013, both users' and producers' accuracy were 100 percent under the grassland class, while there are variations in the accuracy of other classes in the same year. Therefore, in 2013, the overall accuracy is recorded as 96.26 percent, which is very close to 100 percent. This indicates that the map was accurately digitized using the appropriate base reference for digitization and accuracy assessment.

In 2023, vegetation, water body, plantation and road network counts 100 percent accuracy in both users' and producers' accuracy. So, the overall accuracy of the image classification of 2023 is counted as 97.57 percent with correct pixel counts and base maps for references and accuracy assessment of the land use Land cover analyses in the Valpoi town.

**Changes in Areas in LULC Classes**

Valpoi is a town since 1950. It serves all the necessary services in and around the town. The population density of the town was very low from 1960s till 2001. It shows positive growth but there was a sudden decrease in population of the town in 1971. The development of settlement was compact in and around the core centre since post Indian Independence period. One of the most important reasons behind compact residential areas in the town is high concentration of commercial, public and semi-public utility

institutions. With the spatial expansion of the town, the core, fringe and the periphery are increasing along with expansion of settlement in linear axes along the transport lines in the town. Most of the commercial and governmental institutions along with residential development can be seen along these streets in the town. Specially, over the last 10 or 15 years, there has been a significant increase in built-up area in the town exhibiting the occurrence of urban out growth. The increase in built up area in the town can be seen (Figures 3 A & B). The town is expanding slowly overtaking the vegetation and barren land. People prefer to live in the cool and calm environment and that is another reason in decrease in vegetation over a period of time in the town. So, usually the town is expanding in and around its centre making it more congested. Further, reclaiming the forested areas in the north, north east and south west part of town.

**Table 3: Net Change area of LULC classification in Valpoi Town, 2013 to 2023.**

| Land Use Classes | 2013 Area (sq. km) | 2023 Area (sq. km) | Net Change |
|---|---|---|---|
| Vegetation | 8.01 | 7.88 | -0.13 |
| Barren Land | 1.7 | 1.39 | -0.31 |
| Water Body | 0.3 | 0.35 | 0.05 |
| Grassland | 0.03 | 0.03 | 0 |
| Plantation | 0.99 | 1.23 | 0.24 |
| Agriculture | 0.06 | 0.07 | 0.01 |
| Settlement | 0.57 | 0.69 | 0.12 |
| Road Network | 0.29 | 0.3 | 0.01 |
| Total | **11.95** | **11.95** | 0 |

**Major Findings:**

In Goa, rapid urbanization and economic development over recent decades have significantly reshaped the regional pattern of land use and land cover (LULC) in Goa (Roy & Srivastava, 2012). The growing urbanization in Valpoi town has significantly impacted the vegetation with the expansion of settlement areas. The decline in vegetation raises matters of concern for biodiversity conservation in the Western Ghats region, which has been recognized as a biodiversity hotspot zone of India. Vegetation remains the dominant land cover but shows a slight decline from 67.01 percent in 2013 to 65.96 percent in 2023, respectively. The decrease in forest cover is replaced by the expansion of settlements and an increase in plantation activity, especially coconut plantation, which rose from 8.28 percent to 10.33 percent over the decade. A notable decrease is observed in barren land, which is due to the use of the land for plantations and residential use. The area under water bodies like rivers, agriculture and grassland remained nearly constant. This indicates the declining importance of agriculture and a continued shift towards plantation-based activities. The road network also showed a constant change, reflecting some improvement in case of road infrastructure over the last decade. Overall, the change in land use and land cover in the town shows a balanced transformation, where urbanization is not aggressive and maintains its ecological character while giving space for a moderate level of economic development. There is a need for sustainable land use practices that support population and infrastructure growth without harming and compromising the ecological integrity of this sensitive zone.

**Conclusion:**

The study of Land use land cover (LULC) of Valpoi town from 2013 to 2023 shows a gradual yet significant transformation driven by moderate urbanization, diversified economic activities and changing land use preferences. Although vegetation still predominates the urban landscape of the town, slight reduction in forest cover and an increase in built-up areas shows the town's transition towards semi-urban growth. The existence of green spaces, water bodies and little agricultural land indicates that the town continues to preserve its environmental sensitive nature within the Western Ghats Biodiversity-rich region. It is necessary

to implement sustainable land management practices that strike a balance between the demands of development and ecological preservation. Future land use planning must be informed to the common public. Constant monitoring, community engagement and environmentally responsible policies are needed because of the town's strategic location, preservation of natural ecosystem and cultural significance. This study demonstrates that high-resolution satellite imagery and geospatial techniques can effectively monitor land dynamics, providing valuable support to the planners and environmentalists working towards sustainable development in a small town of Goa, namely Valpoi.

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THE KONKAN GEOGRAPHER
Vol. No. 34, June/July 2025, ISSN No. 2277-4858
Impact Factor *(IIFS)* 8.125
(Interdisciplinary Peer Review Refereed Research Journal)

# Assessing the Problems and Prospects of Plantation Agriculture through Sustainable Strategies : A Case Study of Wadi-Talaulim Village, Ponda Taluka, Goa

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**Research Paper Received on 14-06-2025 Edited & Accepted on 30-07-2025**

**Abstract**

*Goa's warm, humid, equitable, and balanced coastal monsoon climate is considered ideal for various tropical agricultural activities, including growing annual, perennial, and horticultural crops, as well as livestock and fish farming. Despite agriculture being a key economic activity in rural Goa, only 16.6 percent of the population is involved in it today, a significant decline from 60 percent at the time of Goa's Liberation in the sixties and around 50 percent in 1987 when Goa became a state. The study was conducted in the primarily agricultural village of Ponda taluka in the State of Goa, specifically in Wadi-Talaulim, highlighting the transformation of plantation agricultural practices and the determinants influencing this change. Through a combination of field surveys, interviews with farmers, and analysis of the data, the study tries to understand the current scenario as well as foresee the prospects of Plantation Agriculture in Wadi-Talaulim. People are driven by short-term and non-agricultural gains, thereby moving away from primary sector into secondary and tertiary sector activities. The study reveals that plantation agriculture has the potential to generate adequate and sustainable income and create potentiality for in situ employment, enhancing the livelihood of the small and marginal farmers who are emotionally tied to their traditional land.*

**Key Words**: equitable climate, horticulture, plantations, perennial, innovations, potential gain

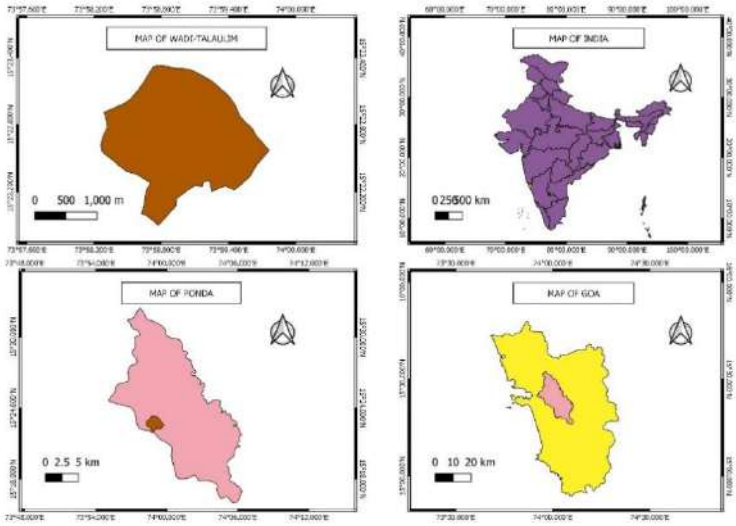
## Introduction:

Historically, agriculture has been primarily subsistence-based until the Industrial Revolution. In India, agricultural systems have deteriorated in both quality and quantity (Mahadevan, 2003). Land use, essential for social and economic development, faces numerous challenges due to socio-economic factors (Hardikar & Tawade, 1990). Traditional orchards, once vital, have declined due to economic pressures (Garbarino & Bergmeier, 2014). In India, colonial systems like the Zamindari, Rayatwari, and Mahalwari shaped land assessments, with the communidade system in Goa making a unique land ownership structure (Dhanda, 2017). However, inefficiencies post-independence led to encroachment on these lands (Gawas, 2018).

Goa's agrarian economy, once sustained by the Mundaka system, saw tenants working land in exchange for a portion of the crops. The Goa Mundkars Act (1975) granted tenants certain rights (Prabhudessai, 2023). Despite agriculture being a key economic activity in rural Goa, only 16.6 percent of the population is involved in it today, a significant decline from 60 percent at the time of Goa's Liberation and around 50 percent in 1987 when Goa became a state (Dr. Singh S.K., Sh. Figueiredo Nelson, Sh. Kelkar Madhav, 2018). To date, more than 2.4 lakh sq. m. of land under plantation has been transformed across the state of Goa (Sequeira N., 2023). The plantation agriculture today is mainly looked after to continue a cultural tradition or passion for nature, deprived of a strong economic purpose (Luick and Vonhoff, 2009).

**Study Area:**

*Fig. 1 Prepared by Research student using QGIS software*




The village of Talaulim lies at 15.3773° N, 73.9730° E, placing it towards the central belt of Ponda Taluka. Etymologically, Talaulim means 'land between three mountains and a river,' whereas the neighbouring village, wadi, refers to a place where few farmers and other villagers inhabit (Talaulicar Pandurang Y, 2018)

Wadi-Talaulim village covers an area of 1.61 square kilometers and is situated near Durbhat, Queula, and Borim and bordered by the Zuari river, with a population of 3,060 across seven wards.

Due to advancements in technology or evolving lifestyles of the local community, there is a drop in plantation agricultural practices. The lands with forests have been cleared, turning them into settlement areas. Some terrains have been transformed into "Manas" or pisciculture farms (Prabhushastri, Indira P, 2014).

**Aim of the study**

To examine the problems and prospects associated with plantation agriculture in Wadi-Talaulim.

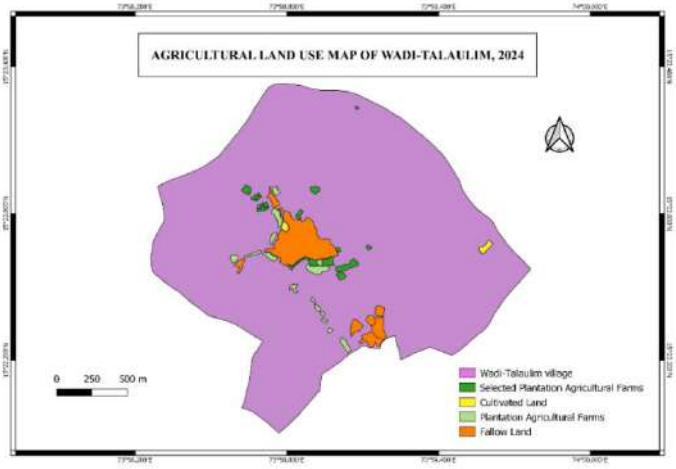
**Data source & Methodology**

The data is derived from both primary and secondary sources. A total of 156 respondents participated in the study, including sixteen case studies. A Random sampling approach was used for 140 samples. A total of 16 farmers (case studies) were interviewed to gain insights into agricultural practices. Utilizing geospatial Waypoints of sixteen plantation agricultural farms, spatial analysis was carried out across the study region.

The data was analysed using Microsoft Excel. The analysis followed a descriptive analysis approach where graphs and charts were interpreted to summarize and describe the key findings.

**Result & Discussion:**

*Fig.2 Prepared by Research student using QGIS software*




Goa has been primarily an agrarian state, but over successive years, the agriculture sector has been shrinking (Herald Goa, 2023). On the contrary, farmers are confronted by multiple constraints, which can significantly affect the sustainability and growth of plantation agriculture in the village. According to the experts, there are three major elements causing individuals to stay away from agriculture: shortage of Labour, high cost of production, and commercialization of the cultivable land (Navhind Times Goa, 2021).

### i. Major challenges encountered by the farmers in Plantation agriculture

One key determinant discourages farmers from growing crops in their plantation agricultural farms. A vast portion of respondents reported that the monkeys invade their farms, destroy their crops, and don't let the crops grow properly. Additionally, due to their other work commitments, they are not able to keep a watch over their farms, which again complicates the problem. Similarly, the availability of labour and irrigation supply is another major challenge stated by the farmers. During summers, farmers particularly face problems regarding water supply, and they are dependent on nearby lakes or ponds for supply of water to their crops. However, during summers, ponds dry up, and as a result, they find it difficult to get enough water for the crops. The plantation agricultural farm involves physical activities, including digging, harvesting, de-husking, etc., which require labours to do all these works, and hiring labour is costly, and it is unaffordable for farmer, in large numbers, especially those farmers who get income primarily from agriculture. Few farmers face the problem of pest and crop diseases like red palm weevil, which can result in the death of coconut trees. Many farmers struggle to identify the invasions early as the symptoms emerge late. Similarly, Bud rot is another disease that has been stated by the farmers. It is very important to treat this disease at an early stage; otherwise, it could kill the tree.

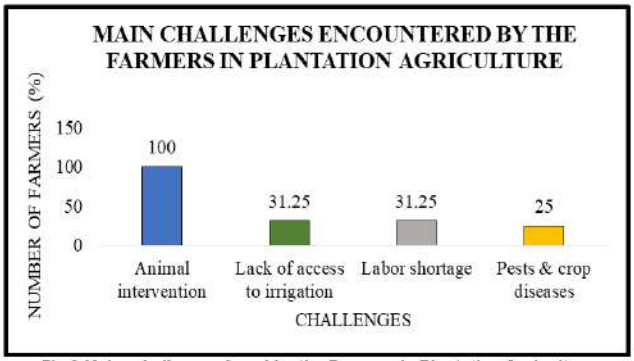



*Fig.3 Major challenges faced by the Farmers in Plantation Agriculture*

*Source: Prepared by Research Student based on Primary data*

### ii. Drivers of Plantation Agriculture

Agricultural work is often seen as labor-intensive and less prestigious as compared to white collar jobs. People no longer want to work physically in the fields but a life that emphasizes on comfort and financial security; hence, 36 percent of the residents believe that as society is developing, people aspire to professions offering them stability, consistent income, and better working conditions.

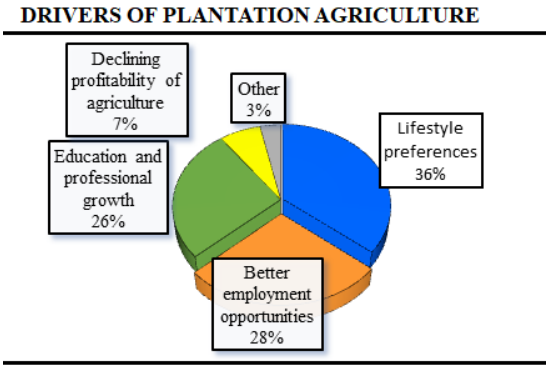



**Fig.4 Drivers of Plantation Agriculture**

Source: Prepared by Research Student based on Primary data

Secondly, Plantation agriculture is a good source of supplementary income, and they have to rely on their other career options, which act as the chief source of earnings for the families. Due to better employment opportunities, which give them consistent income, 28 percent have stated that better employment opportunity is the major driver, which is pushing people away from agriculture. Increased access to education has encouraged people to pursue their careers, and hence, 26 percent of the respondents feel that education and professional growth is a key reason behind people getting away from plantation agriculture. Additionally, 7 percent of locals stated that profitability in agriculture is declining. This is because of the rising costs of labour, agricultural inputs, low returns, and challenges like unpredictable rainfall. In addition to these, various other causes exist for shifting into alternative livelihood options beyond farming, like family migration and land use changes and so on.

### iii. Challenges faced by the Youths in Joining Plantation Agriculture

A disconnect can be seen from traditional agricultural practices and they do not have that bond towards their soil the way their older generations had. Hence, 51 percent of them feel that youths are not

interested in practicing plantation agriculture. Moreover, lack of income is another determinant, as 26 percent of youths reported that increased access to education has encouraged youths to explore the diverse career fields and opportunities.

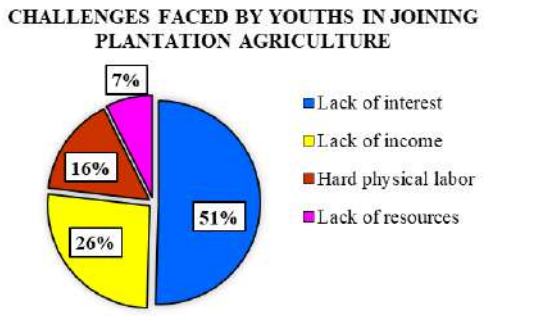



**Fig.5 Challenges Faced by the Youths in Joining Plantation Agriculture**
Source: Prepared by Research Student based on Primary data

Many people view agriculture as less rewarding career as compared to other career opportunities. People perceive that agriculture was capable of generating revenue temporarily. Consequently, individuals have shifted their occupational engagements into secondary and tertiary industries. As the cost of living is also rising, income generated from plantation agriculture cannot sustain the demands of the families. Another key determinant is Hard physical work. In agrarian activity, one has to work hard in the fields. Older generations used to wake up early in the morning and entire day they used to spend working in the fields.

However, now-a-days the lifestyle of the individuals have changed. People are no longer interested in living the traditional old life. The food habits, clothing, culture, way of life can be seen changing over the years. In a similar vein, 7 percent of the individuals expressed owing to inadequate resources, the youth encounter obstacles in engaging with plantation agriculture. In this modern world, using traditional tools and methods in plantation agriculture would not motivate them to get into the field of agriculture. Today's youths are much involved in technology and it would be beneficial if they get access to modern agricultural resources.

**Conclusion:**

The findings reveal that Plantation agriculture is not considered a Primary source of income. However, they treat the income generated from plantation agriculture as a Secondary source as it provides them with a marginal contribution. Today, the cost of living has increased, and it is not possible for the families to solely rely on revenue acquired through Plantation Agriculture. The dominant crops grown on the farms are coconut and areca nut, and farmers sell their produce to Bagayatdar Bazaar, Ponda-Goa. Animal intervention and water scarcity are the two prominent issues faced by the farmers. Farmers are tied to their lands and they want to continue their plantation agricultural activities. However, the younger generation lacks interest. People do not see it as a profession but a traditional, low-status activity that demands hard physical work in the fields. Moreover, individuals are pursuing high qualifications, which offers them wide career opportunities with consistent salaries for comfortable lives.

**Recommesndation**

- **Building Underground Tanks**

Building underground tanks can be really beneficial to the agriculturalists. The water could be consumed to irrigate plantation agriculture farms during the summer. The idea of underground tanks has been inspired by Rajasthan's Underground water tanks policy, which has made it compulsory to build in the interior villages of Rajasthan. Though it's a dry state, water accumulation would not be that high. However, if Goa plans to do so, then it will become self-sufficient in terms of water availability and will not need to worry about water during the hot summers.

- **AI-based Model**

AI tools are being developed in order to make lives easier, and when it comes to agriculture, incorporating AI can be highly beneficial. For instance, Tamil Nadu's E-Velanmai is a pioneering ICT-based advisory system that can give real-time solutions to the agrarians. Hence, if we develop a kind of system or

software wherein agricultural experts provide solutions to the land cultivators when they encounter difficulties in plantation farming regarding soil, pests, weather, etc., this can be useful to the agrarian community.

- **Workshops or Awareness camps for the Agrarians**

Farmers should be educated on how to use digital platforms and tools for farm management. This includes software for tracking crop growth. Supervising resources and analyzing soil conditions. By incorporating farm management tools, Agriculturalists can exercise sound judgment based on real-time data, improving productivity and profitability.

- **Cooperative Farming (Small-scale Model)**

Farmers can collaborate in specific areas, such as sharing farming equipment, bulk procurement of natural fertilizers, or joint marketing of produce to nearby markets. This would reduce individual operational costs, improve bargaining power, and ensure better returns on produce, also, it can foster community solidarity and knowledge sharing among farmers.

- **Aqua-eco Tourism**

Integrating Farming with Tourism, creating a sustainable livelihood strategy that reconnects people with traditional plantation agricultural practices and supports rural development.

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THE KONKAN GEOGRAPHER
Vol. No. 34, June/July 2025, ISSN No. 2277-4858
Impact Factor *(IIFS)* 8.125
(Interdisciplinary Peer Review Refereed Research Journal)

# Drivers and Consequences of Rural Migration: A Study of Ozarim Village in Goa

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**Research Paper Received on 18-06-2025 Edited & Accepted on 26-07-2025**

**Abstract:**

*This study examines the drivers and consequences of rural migration in Ozarim, a village in Goa, India, which has seen notable demographic, environmental, and socioeconomic changes. Using a mixed-methods approach including field surveys, interviews, GPS mapping, and secondary data the research identifies key migration drivers, such as infrastructure projects like Mopa Airport and Ayush Hospital. While migration has boosted economic growth, cultural diversity, and living standards, it has also led to challenges like waste management, water scarcity, and loss of agricultural land. The study calls for sustainable development through inclusive planning, improved waste systems, green space preservation, and education, positioning Ozarim as a model for rural transformation.*

## Introduction:

Migration, a long-standing geographical phenomenon, is driven by livelihood needs, cultural changes, and adverse conditions (Hershner & Chervin, 2014; Behera, 2019). Defined as a lasting change in residence (Lee; Weinberg in Bala, 2017), it continues to shape global demographics. In 2020, international migrants numbered 281 million, with Asia and Europe hosting the most (World Migration Report, 2024). In India, urban growth and economic disparities have fueled migration (Srivastava, 2011). Goa's rural areas, including Ozarim village, have seen increased migration due to tourism, development projects like Mopa Airport, highways, and improved healthcare, offering new job opportunities (Devi & Sudarsan, 2021).

## Objectives:

The main objective of this research is to focus on the Drivers and consequences of rural migration in Ozarim. The objectives are as follows;

- To study about the effects of migration on land use, and the environment in Ozarim village.
- To examine the various factors driving rural migration to Ozarim village.

## Study area:

Ozarim village in Pernem, North Goa, spans 747.43 hectares with a population of 1,669 (Census 2011). It has a sex ratio of 871 and a literacy rate of 75.85%. Out of 646 workers, most are engaged in main work, with few in agriculture. The village has 394 households (PIN 403513) and is governed by an elected sarpanch.

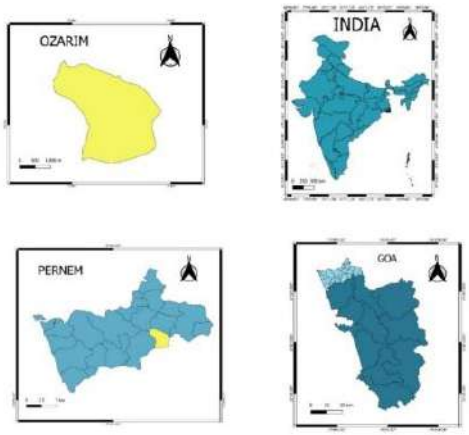



**Fig 1: Study area map**
**Source: Map prepared by author,2025**

**Methodology:**

This study used a mixed-methods approach to examine rural migration in Ozarim. Primary data was collected through field surveys and interviews using structured questionnaires one for migrants (120 samples) and one for local residents (100 samples) selected through random sampling. The surveys focused on demographics, reasons for migration, and its impacts, while interviews captured personal experiences. Geo-tagged photos and GPS points documented landscape changes and surveyed households. Secondary data from government reports, census records, and satellite imagery provided broader context. Statistical analysis helped identify patterns, complemented by qualitative insights to present a comprehensive view of migration in the village.

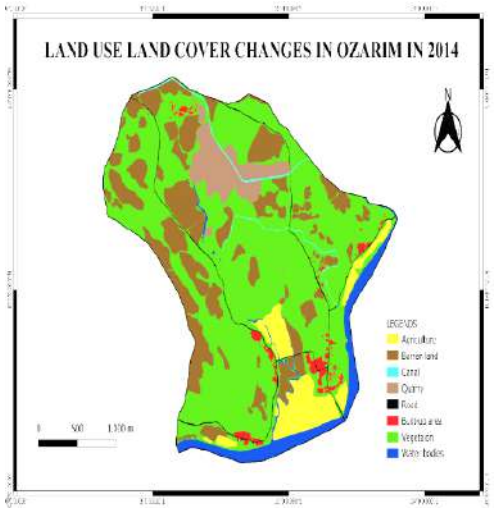
**Analysis**

**1.1 Land Use Land Cover Dynamics (2014 – 2024)**

Land is vital for human activities like farming, housing, and resource use (Acharya, 2021). Land use reflects human needs, while land cover refers to the physical surface—like vegetation or water. Though related, they differ: land cover is observed via remote sensing, while land use involves analyzing human activities.

**A. Land use land cover changes in Ozarim in 2014, Landsat 8 Satellite Image of 2014**

**Fig 2: Land use land cover changes in Ozarim, in 2014**
**Source: Map prepared by author,2025**




The 2014 land use map of Ozarim covers 7.96 sq. km and highlights eight categories. Vegetation was the most dominant, covering 4.65 sq. km (58.45 percent), followed by barren land at 1.70 sq. km (21.31 percent), mainly in the northwest. Water bodies, mainly the Chapora River, covered 0.42 sq. km (5.22 percent), supporting local livelihoods.

Agricultural land (0.51 sq. km / 6.36 percent) was concentrated near the river, where traditional crops like groundnuts and cowpeas were grown. Built-up areas (0.14 sq. km / 1.80 percent) were located mostly in the south. Quarries (0.43 sq. km / 5.35 percent) were active for construction, while canals (0.04 sq. km / 0.51 percent) supported irrigation. Roads (0.08 sq. km / 0.99 percent) improved connectivity and access to services.

**B. Land use Land cover changes in Ozarim in 2024, Landsat 8 satellite image of 2024**

The 2024 map of Ozarim shows land use changes, covering eight categories: Water bodies, Built-up areas, Agriculture, Barren land, Canal, Quarry, Roads, and Vegetation. Vegetation became the dominant cover at 6.13 sq. km (77.21 percent), indicating afforestation and natural growth. Water bodies covered 0.41 sq. km (5.20 percent), mainly the Chapora

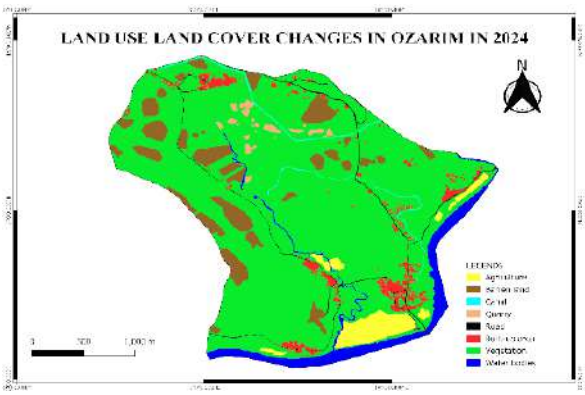



**Fig 3: Land use land cover changes in Ozarim in 2024**
**Source: Map prepared by author,2025**

River. Built-up areas expanded to 0.27 sq. km (3.39 percent), while barren land reduced to 0.66 sq. km (8.27 percent), likely due to development. Agriculture declined to 0.26 sq. km (3.33 percent), concentrated near the river. Canals (0.04 sq. km / 0.53 percent) supported irrigation. Quarry areas decreased to 0.07 sq. km (0.89 percent), and roads grew slightly to 0.09 sq. km (1.18 percent), improving connectivity.

**C. Comparative analysis**

The comparative land use analysis of Ozarim village between 2014 and 2024 reveals significant transformations. Agricultural land declined from 6.36% to 3.33%, likely due to a shift in livelihoods toward tourism, rentals, and service-based activities. Barren land reduced markedly from 21.31% to 8.27%, suggesting conversion into vegetation or built-up spaces. Built-up areas increased from 1.80% to 3.39%, reflecting expanding settlements and infrastructure. Roads also saw a slight rise, from 0.99% to 1.18%, supporting this trend. Vegetation recorded the highest growth, rising from 58.45% to 77.21%, possibly due to natural regeneration, afforestation, or abandonment of farmland. Quarry areas decreased sharply from 5.35% to 0.89%, indicating reduced extraction or repurposing. Canals showed a minimal increase (0.51% to 0.53%), and water bodies remained nearly unchanged, with a slight drop from 5.22% to 5.20%. These changes highlight a shift towards greener land cover and urban expansion in Ozarim over the decade.

## 1.2 Determinants Affecting Rural Migration:

Migration is a complex response to local and global conditions, influenced by economic, social, political, and environmental factors. It involves the movement of people either within a country as internal migration or between countries as international migration. Emigrants leave their homeland, while immigrants enter a new country to settle. People migrate for various reasons: economic such as seeking jobs or avoiding famine, social such as better quality of life or family connections, political such as escaping conflict or persecution, and environmental such as natural disasters like floods or droughts. In India, migration is driven mainly by unemployment and low farming productivity.

**A. Lee's theory of migration**

Everett Lee's theory of migration (1966) explains migration through push and pull factors along with intervening obstacles. Push factors are negative conditions that drive people to leave, such as poverty, poor job prospects, disasters, or lack of services. Pull factors are positive attractions like better opportunities, education, healthcare, and quality of life. Intervening obstacles are challenges faced during migration, such as physical barriers, legal issues, economic costs, and social or cultural difficulties. Intervening opportunities are unexpected benefits like jobs or better living conditions that may cause migrants to settle before reaching their intended destination.

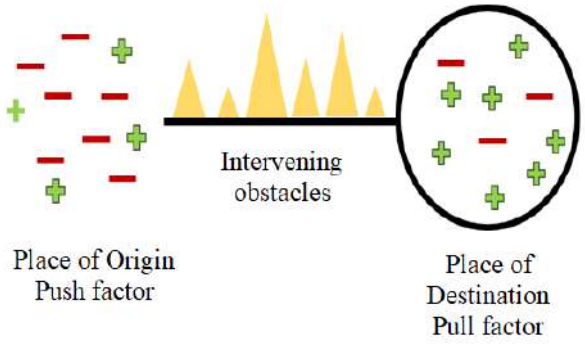


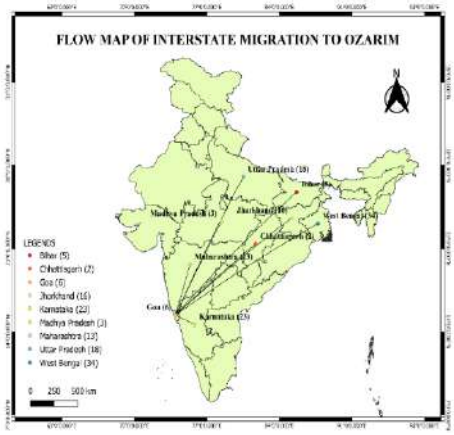

**Fig. 4: Lee's Theory of Migration**
**Source: Prepared by author,2025**

**1. Native place of residence of migrants in Ozarim**

The flow map illustrates the origin of migrants in Ozarim village by state. West Bengal leads with 28.33 percent, followed by Karnataka (19.17 percent), Uttar Pradesh (15.0 percent), and Jharkhand (13.33 percent).

Maharashtra adds 10.83 percent, while smaller contributions come from Goa, Bihar, Madhya Pradesh, and Chhattisgarh. The notable presence of migrants from neighbouring states indicates regional mobility, mainly for employment and improved living conditions.

**Fig. 5: Flow Map of Interstate Migration to Ozarim Source: Map prepared by author,2025**




2. **Major challenges faced by migrant's place of origin:** The bar graph shows the main challenges migrants faced before moving to Ozarim. Lack of employment is the top reason (95 percent), and lack of social facilities (25 percent).

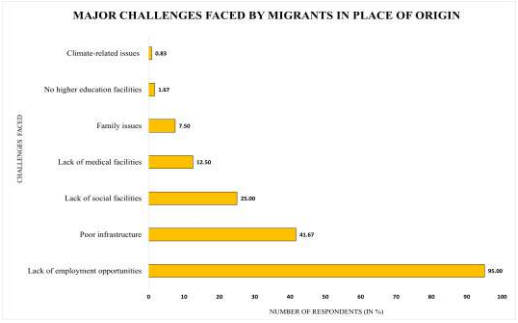



**Fig 6: Major challenges faced by migrant's place of origin**
**Source: Graph prepared by author,2025**

3. Other issues include limited medical care (12.50 percent),
4. family problems (7.50 percent), lack of higher education (1.67 percent), and climate issues (0.83 percent). Overall, economic and infrastructural factors are the key drivers of migration.

5. **Barriersaced during migration journey**

The chart shows key barriers migrants faced while moving to Ozarim. The main challenges were high travel costs and cultural differences (43.33 percent), followed by emotional stress of leaving home (10.83 percent) and fear of discrimination (8.33 percent). Minor concerns included health risks and lack of information (0.83 percent each). Notably, 19.17 percent reported no challenges. Overall, financial and cultural hurdles were the most significant.


**Fig. 7: Barriers faced during migration journey**
**Source: Graph prepared by author ,2025**

6. **Key drivers of m igration in Ozarim**

The bar graph highlights key migration drivers to Ozarim. Employment opportunities (97.50 percent) and better income (72.50 percent) are the main reasons, showing strong economic motivation. Other factors like improved living conditions (29.17 percent) and infrastructure (23.33 percent) also influence migration. Personal reasons such as family issues, marriage, healthcare, and education account for minimal responses. Overall, economic factors are the primary drivers of migration to Ozarim.

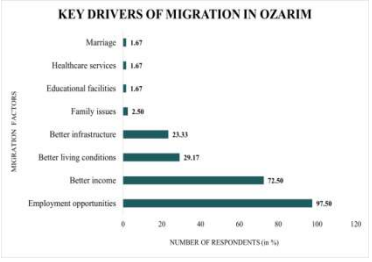



**Fig. 8: Key drivers of migration in Ozarim Source: Graph prepared by author,2025**

## 1.3 SUSTAINABLE DEVELOPMENT MEASURES

Ozarim village is undergoing migration-led development, resulting in land use changes, reduced agriculture, deforestation, and environmental issues like water scarcity and biodiversity loss. Sustainable actions such as afforestation, water conservation, eco-friendly building, and improved waste management, along with community involvement, are key to achieving balanced growth and ecological stability.

**A. Strategies for Sustainable Development in Ozarim**

To ensure balanced growth in Ozarim, a mix of community awareness, environmental protection, and improved infrastructure is essential. Key strategies include:

1. **Environmental Conservation**
   - Promote tree planting drives, especially of local species like cashew and coconut, with support from the Panchayat and government subsidies.
   - Encourage rainwater harvesting, modern irrigation (e.g., sprinklers), and construction of recharge wells.
   - Educate residents on waste segregation and composting; improve waste collection and recycling systems.
2. **Improved Infrastructure**
   - Develop eco-friendly transport (e.g., electric vehicles, public transport).
   - Promote renewable energy through solar panel subsidies.
   - Build better drainage systems to prevent flooding.
3. **Affordable Housing**
   - Introduce rent control and support schemes for low-income groups.
   - Ensure zoning laws balance residential, commercial, and agricultural land use.

**B. Action Plans for Sustainable Development in Ozarim**

**Install recycling cages**

Install recycling cages at key spots to help residents and migrants dispose of garbage at their convenience, improving cleanliness and collection


**Fig. 9: Action plan for better waste disposal in Ozarim.**
**Source: Map prepared by author,2025**

**Conclusion:**

1. **Segregation Bins:**
   Distribute separate bins for wet and dry waste to promote proper waste management and ease collection.
2. **Helpline & Awareness**:
   Launch a local helpline to report water issues and organize awareness drives on waste management and environmental conservation.

Ozarim, a culturally rich village in Goa, has seen major changes in land use, economy, and society from 2014 to 2024. Once largely agricultural, the village now shows increased vegetation due to afforestation, while many residents have shifted to non-farming jobs. Improved infrastructure and migration from states like West Bengal and Uttar Pradesh have boosted diversity and economic activity but brought integration challenges. Environmental issues like waste, water scarcity, and habitat loss have led to a focus on sustainable development. Ozarim aims to balance growth with environmental care and cultural preservation for a better future.

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THE KONKAN GEOGRAPHER
Vol. No. 34, June/July 2025, ISSN No. 2277-4858
Impact Factor *(IIFS)* 8.125
(Interdisciplinary Peer Review Refereed Research Journal)

# Water Quality Analysis of a Wetland Ecosystem with Special Reference to Ramsar Site : Nanda Lake in Quepem-Goa

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**Research Paper Received on 22-06-2025 Edited & Accepted on 30-07-2025**

**Abstract**

*Wetlands are vital ecosystems that provide numerous ecological, hydrological, and socio-economic services. They function as natural water filters, biodiversity hotspots, and climate regulators. This research investigates the seasonal water quality dynamics of Nanda Lake—Goa's first Ramsar site. By examining physical, chemical, and microbial parameters during the monsoon and post-monsoon seasons, the study seeks to uncover the influence of seasonal and anthropogenic factors on wetland health. The findings indicate significant deviations from permissible standards during the monsoon, with notable contamination in terms of turbidity and coliform presence. While post-monsoon water quality shows improvement, certain contaminants remain elevated. The study contributes to a growing body of research on wetland conservation in India and highlights the urgency for community-based and policy-driven conservation strategies to preserve the integrity of fragile aquatic ecosystems.*

## Introduction

Nanda Lake is a Ramsar site located in Goa, a small state in India. On 22 July, Nanda Lake was recognised as the first Ramsar site of Goa. Wetlands are among the most productive ecosystem on earth. It plays crucial role for various living beings. It is home to many bird species, animal species, plant species and micro-organisms. Lake is a water body that supports many living beings. The lakes attract people towards them. The water quality test was performed of the lakes to understand the quality of water. The test was done in two periods; Monsoon and the Post Monsoon. Five water samples were collected of the lakes in monsoon and post monsoon period. The analysed were done on physical, chemical and bacterial parameters. This test was carried out to gain the understanding of water quality of Ramsar site. In recent years, wetlands across the globe have received scientific as well as political attention (Kimmel et al., 2010) as most of them are under threat due to anthropogenic pressure (Turner and Rabalais, 1991, Marsden et al., 1997, Carpenter et al., 1998). A better understanding of the physical, chemical and biological characteristics of wetlands and their impacts is necessary for the successful conservation of these important aquatic systems (Carpenter et al., 1998). (Tuboi et al., 2018).

## Objectives

1. To analyse seasonal variations of physico-chemical and microbial parameters of Nanda Lake.
2. To suggest strategies for sustainable conservation and protection of the lake ecosystem.

## Study area:

Nanda Lake situated in Quepem Taluka of South Goa. Its longitude and latitude are 15 15'37" N and 74 06'30" E. Lake is designated as Ramsar site in 2022 with an area of 64.47 ha. It is a natural inland type of wetland. Depth of the lake is 1-2 meters maximum; elevation is 7m above mean sea level. Main source of water regimes is rainfall and catchment runoff. Lake's water permanence is permanent in nature. It situated near a major tributary of the Zuari River. A sluice gate connects the marshes to the river and when closed it allows the marshes to flood.

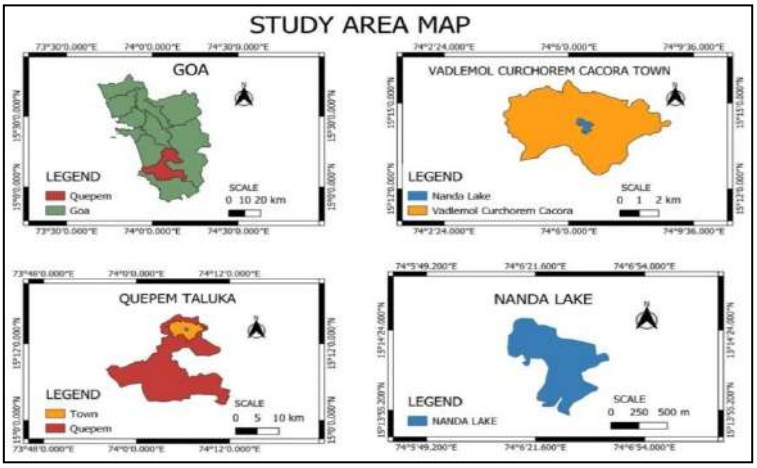


**Fig – 1.1:** Study area map
**Source:** Mapping done by research student, 2025

**Methodology:**

This study employs a field-based, comparative, and seasonal analysis of water quality parameters from freshwater lakes. Water samples were collected from five geo referenced locations in each lake during two key seasonal phases; the monsoon season in July 2024 and the post-monsoon season in December 2024. The parameters were analysed in accordance with the standard testing protocols outlined by the Bureau of Indian Standards (BIS).

The selected parameters include:

- **In Physical**, pH and turbidity were analysed.
- **In Chemical**, Total dissolved solids (TDS), total hardness, calcium, magnesium, iron, manganese, alkalinity, and chlorides were measured.
- **In Microbial,** Most Probable Number (MPN) of total coliforms and Escherichia coli were analysed.

The collected data were subjected to comparative statistical analysis and visualized through tables. Each value was evaluated against BIS standards for water quality to determine the safety and suitability for various uses.

**Result and Discussion** **Table** 1.1 – Water Quality Analysis of Nanda Lake during Monsoon.

| Sr. No. | Test | Nanda | | | | | Quality Standard | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Acceptable | Cause of Rejection |
| | Physical Analysis [Units] | | | | | | | |
| 1 | PH | 7 | 6.7 | 6.7 | 6 | 7 | 6.5 to 8.5 | <6.5 or >8.5 |
| 2 | Turbidity [N.T.U] | 3.8 | 14.3 | 6.4 | 14.5 | 16.9 | 5 | 10 |
| | Chemical Analysis [Units] | | | | | | | |
| 1 | Total Alkalinity as CaCo3[mg/l] | 21 | 13 | 20 | 16 | 18 | 200 | 600 |
| 2 | Total Hardness as CaCo3[mg/l] | 21 | 16 | 20 | 15 | 14 | 300 | 600 |
| 3 | Chlorides as Cl-[mg/l] | 6.9 | 5.9 | 5.9 | 5.9 | 5.9 | 200 | 1000 |
| 4 | Manganese as Mn++as[mg/l] | 0.3 | 0.2 | 0.1 | 0.3 | 0.2 | 0.1 | 0.3 |
| 5 | Iron as Fe++[mg/l] | 0.58 | 0.54 | 0.78 | 0.59 | 0.58 | 0.3 | 1 |
| 6 | Residual chlorine [mg/l] | Nil | Nil | Nil | Nil | Nil | [0.2 min] | Nil |
| 7 | Calcium [ca++] | 7.2 | 5.6 | 6.4 | 5.2 | 4 | 75 | 200 |
| 8 | Magnesium [mg++] | 0.75 | 0.5 | 1 | 0.5 | 1 | 30 | 150 |
| 9 | Specific Conductivity | 25.3 | 25.3 | 25.2 | 25 | 24.9 | | |
| 10 | TDS | 16.1 | 16.1 | 16.1 | 16 | 15.9 | | |
| | Bacteriological Analysis [Units] | | | | | | | |
| 1 | MPN of coliform organisms/100ml | 39 | 1600 | 33 | 920 | 540 | | |
| 2 | MPN of E-Coli/100ml | 33 | 350 | 27 | 220 | 170 | | |

**Source** – Water test report from Salauli water treatment plant.

Water is an important aspect of a human life and an important part of nature's heaven. To understand the water quality is also a crucial point in human's life. The above table shows the water quality of a Ramsar wetland that is Nanda Lake in Quepem Taluka of Goa. the physical, chemical and biological characteristics of a lake is analysed using parameters like PH, turbidity, alkalinity, hardness, chlorides, manganese, iron, residual chlorine, calcium, magnesium, specific conductivity, Total dissolved solids, MPN of coliform organisms and e-coliform are taken into consideration while analysing the water test. Each parameter shows each category present in the water. Five sample of water has taken from different point of lake during monsoon. Every parameter has a acceptable range and a cause of rejection that differ from parameter to parameter. The PH value is more sample number 1 and 5 and slightly low in other samples but lies in acceptable range that means water is neutral and can be consumed by all organisms. The turbidity is low in sample 1 and in rest 4 samples it is above cause of rejection range. Alkalinity is very low in the lake as it is natural lake and does not contain any soil particles. The hardness of the water is very light because it does not contain any waste materials. Chlorides is also present in the water but it is little amount of range. Manganese is present in the acceptable range in all the samples. Iron content is also present but above the acceptable range. Chlorine is not present in the water as the water is not used for drinking. The calcium and magnesium content is very less in the lake. Specific conductivity is 25 in the lake. Total dissolved solids are 16 in values as people throw some used flowers in the lake the biological characteristics are also present in the lake in the form of coliform and e-coliform of organisms. His are the parameters included in the testing in monsoon period.

**Water quality of Nanda Lake during post monsoon**

**Table**.2 water quality of Nanda Lake during post monsoon

| Sr. No. | Test | | | | | | Quality Standard | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Acceptable | Cause of Rejection |
| | Physical Analysis [Units] | | | | | | | |
| 1 | Ph | 7.5 | 7.17 | 7.8 | 7.12 | 7.2 | 6.5 to 8.5 | <6.5 or >8.5 |
| 2 | Turbidity [N.T.U] | 7 | 6.9 | 7.1 | 6.6 | 11.2 | 5 | 10 |
| | Chemical Analysis [Units] | | | | | | | |
| 1 | Total Alkalinity As Caco3[Mg/L] | 18 | 17 | 17 | 16 | 20 | 200 | 600 |
| 2 | Total Hardness As Caco3[Mg/L] | 20 | 18 | 17 | 19 | 21 | 300 | 600 |
| 3 | Chlorides As Cl-[Mg/L] | 6.5 | 7.5 | 7.5 | 9 | 9.5 | 200 | 1000 |
| 4 | Manganese As Mn++As[Mg/L] | Nil | Nil | 0.2 | 0.05 | 1.2 | 0.1 | 0.3 |
| 5 | Iron As Fe++[Mg/L] | 1.44 | 1.23 | 1.68 | 1.3 | 3.24 | 0.3 | 1 |
| 6 | Residual Chlorine [Mg/L] | Nil | Nil | Nil | Nil | Nil | [0.2 min] | Nil |
| 7 | Calcium [Ca++] | 4 | 2 | 3.5 | 1.5 | 1.5 | 75 | 200 |
| 8 | Magnesium [Mg++] | 1.75 | 2.25 | 1.25 | 2.75 | 3.25 | 30 | 150 |
| 9 | Dissolved Oxygen [Mg/L] | 7 | 7.5 | 8.1 | 7.7 | 7.8 | | |
| 10 | Specific Conductivity | 78.4 | 125.7 | 72.3 | 68.9 | 68.9 | | |
| 11 | Tds | 39.7 | 62.8 | 36.2 | 34.5 | 34.5 | | |
| | Bacteriological Analysis [Units] | | | | | | | |
| 1 | MPN Of Coliform Organisms/100ml | 23 | 23 | 43 | 21 | 23 | Nil | Nil |
| 2 | MPN Of E-Coli/100ml | 7 | 7 | 11 | 4 | 9 | Nil | Nil |

**Source** – water test report from Salauli water treatment plant.

The above table show the water test report of Nanda lake in post monsoon. The test is carried out in the month of January to know the quality of water in lake. The quality of water is carried out in three analyses namely physical, chemical and biological. In physical analysis PH value and turbidity was took into consideration. In Chemical analysis Alkalinity, Hardness, chlorides, Manganese, Iron, Calcium, Magnesium, Specific conductivity, TDS was carried out and in biological analysis MPN of coliform and e-coliform of organisms had done of the lake. In the post monsoon the PH level of Nanda Lake is within the acceptable range. The turbidity ranges from 7 to 11. In chemical analysis the alkalinity, hardness, chlorides was low. Manganese in two sample it was nil whereas in other samples it was above the acceptable value. Chlorine

was nil as it is natural lake. Calcium and magnesium was low. Dissolved oxygen was between 7 to 8.1 ranges. Specific conductivity in Nanda Lake during post monsoon varies from 68.9 to 78.4 in four samples and only second sample it was 125.7. total dissolved solids in the lake ranges from 34 to 62. Bacteriological analysis was also carried out and the parameter taken was MPN of coliform and e-coliform. From the above analysis, understood the water quality of Nanda Lake in post monsoon.

**Comparative analysis of Nanda Lake during monsoon and post monsoon:**

The above graph shows the comparative analysis of water quality of monsoon and post monsoon of Nanda Lake in Quepem Taluka. The samples were taken during monsoon, five samples and during post monsoon five samples were taken in order to study the quality of water. The physical, chemical and bacterial parameters of water were analysed. The graph denotes the blue colour to monsoon and red colour to post monsoon. The PH level of both the seasons was neutral but in monsoon the PH is low as compared to post monsoon. Turbidity of monsoon and post monsoon differs according to the samples. In some samples it is increasing as well as decreasing in both the seasons which depicts the turbidity is suspended over the lake. In chemical analysis, the alkalinity is below the permissible range. The alkalinity also varies sample to sample in both the seasons. The hardness level of the water is also low and differs in both the seasons and varies sample too sample. This shows the water is fit and can be used for other purposes. The chloride low during monsoon but is high in post monsoon compared to monsoon. The manganese is moderate in monsoon but in post monsoon it is absolutely nil in starting two samples and suddenly increases in sample five. The iron content is low in monsoon but rises in post monsoon period. The content of calcium is high in monsoon but low in post monsoon period. The magnesium is low during monsoon and increases in post monsoon. Specific conductivity and total dissolved solids are very little amount but increases during post monsoon. the bacterial analysis indicate that MPN of coliform organisms and MPN of E-Coli is low in monsoon com increases in post monsoon. This is because in monsoon the water gets dissolved due to rain but in post monsoon the water didn't get dissolved with other factors and organisms get contaminated.

**Suggestions**

- Strengthen education and outreach programs to promote awareness of wetland conservation.
- Construct proper waste disposal and sewage systems in surrounding areas.

**Conclusion:**

The present study is a starting effort to understand the health of the water. The analysed parameters are helpful for the local people. As per the report the quality of water is good for the different purposes but not useful for the drinking purpose. These wetlands help in regulating the water cycle and support different flora and fauna. The findings indicate that human activities have altered the wetlands natural processes leading to water pollution, habitat degradation and biodiversity loss.

The study underscores the urgency of implementing sustainable conservation strategies. Strengthening wetland management through scientific monitoring, community participation is essential. Sustainable wetland management requires active involvement of local communities. Awareness programs, eco-tourism can help reduce dependency on wetland resources while promoting conservation.

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THE KONKAN GEOGRAPHER
Vol. No. 34, June/July 2025, ISSN No. 2277-4858
Impact Factor *(IIFS)* 8.125
(Interdisciplinary Peer Review Refereed Research Journal)

# Marketing of Flower Cultivation in Solapur District, Maharashtra, India

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**Research Paper Received on 30-06-2025 Edited & Accepted on 30-07-2025**

## Abstract

*Agricultural marketing refers to the resources that go into getting a crop from the farm to the customer. These services include preparing, arranging, directing, and handling agricultural products in such a way that growers, intermediaries, and consumers are satisfied.Planning production, growing and harvesting, grading, packing and shipping, transport, storage, agro- and food processing, market knowledge, distribution, advertisement, and selling are only a few of the interconnected activities involved.Flower cultivation is regarded as a profitable and high-returning agricultural industry.*

**Keywords:** Cultivation of flowers, Marketing activities, Floriculture, Employment.

## Introduction

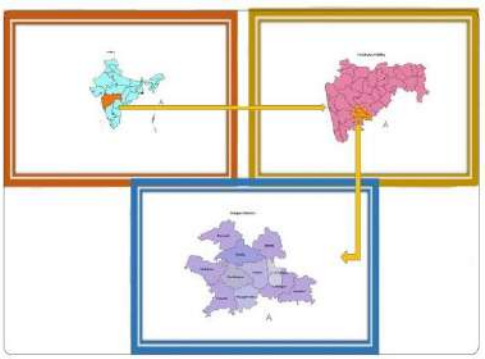
India's 'flower strength' continues to expand, with the country now ranking as the world's second largest grower of flowers.Flowers are integrally linked to the social fabric of life. Flowers, as God's adorable conception, are appropriate for all occasions, including birth, marriage, and death. Flowers were once insignificant in terms of economics.To satisfy one's aesthetic desires, one would grow flowers. Flowers were occasionally sold for sale to meet people's specific needs. With the passing of time, people's lifestyles have changed dramatically, resulting in the commercialization of flower cultivation.Floriculture means the cultivation of flower and ornamental plants within the garden and arable land (Biswas, 2013) for commercial purposes (Mishra and Mishra, 2016). India has managed to increase the production of flowers which are having a huge potential for export (Prakash and Muniyandi, 2014).Flowers are one of the most lucrative products, with one of the best returns of any specialty crop.The traditional flowers like marigold, jasmine, chrysanthemum, china aster, crossandra, tuberose, rose petals occupy nearly two thirds of the total area and forms the backbone of Indian floriculture, which is mostly in the hands of small and marginal farmers (Sindhu and Saha, 2010).

## Study Area

In the Indian state of Maharashtra, the Solpaur district is located. Solapur district has latitudes ranging from $17^0$10' N to $18^0$ 32' N and longitudes ranging from $74^0$ 42' E to $76^0$ 15' E.

The district's east-west and north-south lengths are approximately 200 and 150 kilometres, respectively.According to the 2011 census, the total population of Solapur district is 43,15,527 and the geographical area is about 14,895 sq. km divided into 11 tahsils (Barakade and Sule, 2011). Among the 35 districts in

Figure 1: Location map of the study area.



Maharashtra, it ranks fourth in terms of area (4.88 percent) and seventh in terms of population (4.51 percent).Since the study area is in a rain shadow, the district's average annual rainfall is 584.3 mm.

**Concept of Floriculture**

Floriculture, also known as flower farming, is a branch of horticulture concerned with the cultivation of flowering and ornamental plants for use in gardens and floristry.Bedding plants, flowering plants, foliage plants or houseplants, cut cultivated greens, and cut flowers are all examples of floriculture crops. Traditional and modern flower crops are used in floriculture.

**A) Loose Flower:-**

Flowers have traditionally been cultivated in open fields in India and Maharashtra. The traditional way of farming is open field planting. In open field flowers are also known as Loose flowers. i.e. Jasmine, Marigold, Rose, Tuberose, Aster, Hibiscus, Chrysanthemum etc.

In this study region, there was a lot of loose flower production. As a result, loose flowers in local markets are in high demand.

**B) Cut flowers :-**

Cut flowers have recently captured the attention of urban culture. The majority of Non-traditional flowers are cultivated in controlled environments, i.e. Gerbera, Carnation, Dutch rose, Chrysanthemum, Gladiolus, Orchids, Lily etc.It is typically cut from the plant and used as a decorative item. In this research area, there were very few green houses. Cut flowers are always imported from other district markets as a result.

**Importance of Flowers**

Flowers are essential in nature because they can feed insects, birds, livestock, and humans; they can also provide natural medicines for humans and some animals; and they can help a plant reproduce by attracting pollinators from the outside. Plants would be simply green without flowers, and the earth would be a duller place.Plant Reproduction – The flower is the plant's reproductive organ. That is what produces the fruit or vegetable that we consume (following pollination). It's also where the seed is made, ensuring that more of the same plant grows in the future.

**Flowers of Medicinal Importance**

In recent years, modern scientists have been drawn to the indigenous system of medicine, especially Ayurveda, in search of cures for a variety of difficult diseases. The World Health Organization has stated that herbal medicines meet the health needs of approximately 80% of the world's population, especially millions of people living in large rural areas of developing countries.The effectiveness of plant medicines relative to the adverse side effects of most modern medications has resulted in a recent revival of plant remedies.

**The Scope of Floriculture**

The scope of floriculture is related only to the Information Technology Industry in terms of global reach, and it is expanding at a rapid pace. Floriculture is both an industry and a reliable source of income. Floriculture is a very common marketing trend right now. Flowers are used in all private banks, large hospitals, corporate houses, and event management firms.

**Area and Production of Flowers in Solapur District**

The area under flower cultivation in the Solapur district is small due to the rain shadow, but with a little effort, flower production can be increased. Irrigation services, flower plant quality, fertilisers, as well as pesticides, all need the

Area and Production of Flowers in Solapur District

| Sr. No | Flowers | Area (in Ha) | Production (In Tonnes) |
|---|---|---|---|
| 1 | Rose | 59.86 | 1400.45 |
| 2 | Marigold | 197.85 | 2698.85 |
| 3 | Chrysanthemum | 86.48 | 520.88 |
| 4 | Jasmine | 9.13 | 47.57 |
| 5 | Tuberose | 19.35 | 317.7 |
| 6 | Gerbera | 0.7 | 12.29 |
| 7 | Carnation | 0.15 | 0.15 |
| 8 | Gladiolus | 1.96 | 8.81 |
| 9 | Gaillardia | 17.21 | 193.47 |
| 10 | Other flowers | 56.46 | 892.2 |
| | Total | 449.15 | 6092.3 |

Source: Socio-Economic abstract of Solapur district 2010-11

attention of flower growers in high output. Floriculture is a profitable industry.

Landholders are classified in to three categories based on the scale of their holdings: small, medium, and large. Many with a strong financial position take advantage of new technologies to increase their profits. Owing to a lack of funds, the remaining are unable to come up with them because they are not using new technology.Natural disasters such as excessive rainfall, drought, and cyclones are other issues that all farmers, regardless of financial standing, must deal with. Another issue facing producers is a lack of education. They can't find the right soil or crop.

Flowers are sensitive to being sold in a short period of time, so preservation is a concern. Due to a lack of accessories to conserve the flower, growers are forced to look for a market for their product.In terms of marketing, the grower faces several challenges, including quality control, packaging, cold storage, and time and price management. The grower's income is boosted by high price fixing, but he doesn't have the same opportunity in marketing. It is the responsibility of merchants and middlemen.

**Marketing of Flowers**

Flower marketing in India is currently very disorganised. Flowers are brought to wholesale markets, which are often located in open yards, in most metropolitan cities with a wide demand potential. The majority of the produce is purchased by a few large flower merchants, who then sell it to local retail outlets after a substantial markup.Retail florist shops are often found on the side of the road, with various flowers set in big buckets. However, there are some strong florist showrooms in the metros, where flowers are held in regulated temperature conditions and value-added service is prioritised.The government is now investing in the establishment of auction platforms as well as well-organized florist shops with improved storage facilities to extend shelf life.

**Solapur Market yard: Flowers Price**

| Sr. No. | Name of Flowers | Min-Max price Price /Rs (Per Kg) | Duration |
|---|---|---|---|
| 1 | Rose | 80-300 | Yearly |
| 2 | Marigold | 20-200 | Yearly |
| 3 | Chrysanthemum | 80-250 | Winter |
| 4 | Tuberose/Nishigandha | 100-300 | Yearly |
| 5 | Jasmine/ Mogra | 100-800 | Summer |
| 6 | Gerbera | 15-20 Rs Per item | Yearly |
| 7 | Gaillardia | 15-30 Rs Per bunch | Yearly |
| 8 | Kakada | 20-120 Per packet | Rainy and winter |
| 9 | Aster | 3-4 Rs Per item | Rainy and winter |
| 10 | Lilium | 15-20 Rs Per bunch | Rainy and winter |

Source: Compiled by Researcher

Flowers are usually packaged and transported from the output canter to wholesale markets in a rather unscientific manner. The flowers are packed in old gunny bags, bamboo baskets, simple cartoons, or simply wrapped in old newspapers and transported to markets by road, rail, or air, depending on the type.

The mode of transportation is determined by the distance between markets and the amount of goods to be transported. Flowers are usually picked in the evenings and transported by overnight trains or buses to neighbouring cities.

**Infrastructural and Marketing Facilities for Floricultural Products:**

Farmers in the Solapur District have expressed a strong desire to grow a large variety of loose and cut flowers. Off-season output advantages, when combined with demand advantages, offer a lot of space for remunerative rates.Consumers of flowers who live far away from production areas have no direct interaction with growers. Various intermediaries, such as forwarding agents, cooperative societies, wholesalers/ commission agents, and retailers, fill this void between producers and customers. They collaborate to provide various marketing services.

These organisations are an important part of the system because they develop the mechanics for determining rates, different arrangements and connections, and ensuring the flow of goods and services. The marketing channels used by the survey respondents for the sale of flowers.

The marketing chain between the production point and the market in Solapur Market Yard is fairly well-functioning. Flowers from remote growing centres make their way to the flower market through middlemen and, in some cases, personal efforts..

**Marketing Efforts:**

The florists make no special marketing attempts because the larger ones are well-known in the city due to word-of-mouth publicity. Emerging internet-based orders, on the other hand, necessitate web-advertising. Although there are few attempts made in terms of advertisement or other marketing aspects, it has been observed that tie-ups with wedding halls, hotels, and corporate offices are frequently used to maintain the company.

**Storage Requirements/ Conditions:**

With small florists, flowers are usually stored in standard room conditions with a two-day shelf life. Because of their age, the flowers do not suffer a significant price drop during this period. Large florists, on the other hand, often see stock remaining for 6-7 days, resulting in a price depreciation of nearly 50%.

**Production Problems**

More than 60% of growers said they didn't know how to use the new up-to-date processing methods. Inadequate and timely supply of dependable plant material. Furthermore, the lack of skilled labour, especially during times of unique operations, impedes production efficiency. Most growers do not schedule their crops according to the festive seasons or the needs of target markets, and as a result, they are unable to obtain remunerative prices. As a result of the gap in the implementation of production technology, the majority of growers are not adopting the recommended package of practises, resulting in low production efficiency.

**Problem of Floriculture Marketing in Solapur District**

Marketing is the exchange of money for the actual transfer of ownership of a product from the manufacturer to the customer. As a result, any producer requires someone to agree to buy his goods. Traders, market functionaries, middlemen, intermediaries, and direct customers are all words used to describe the above group of people.Apart from the general issues mentioned earlier, the floricultural marketing sector in the area is plagued by a number of issues. These issues can be classified into the following categories:

- Market-yard related problem.
- Marketing problem.
- Infrastructural problem
- Pricing problem resulting in distress sale.
- Transportation problem.
- Problem of market regulation.
- Availability of labour
- Sources of finance

Growers are forced to rely solely on local intermediaries. At a competitive or remunerative price, the markets are unable to absorb the entire arrival. As a result, the farmers bear the brunt of the consequences.

- Infrastructural problem
- Poor transportation network
- Problem of market regulation
- Wastage and risk

## Conclusion

Individual growers in the Solapur district practise small-scale floriculture due to the high cost of production inputs, especially imported plant material, and the district's scattered and small land holdings.The study found that the area of flower cultivation in Maharashtra's Solapur District remained constant throughout the study period, but that flower cultivation fluctuated. Farmers knowledge of proper post-harvest handling, packaging, storage, and transportation has not yet advanced to a sophisticated level. They are unfamiliar with modern marketing techniques.

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THE KONKAN GEOGRAPHER
Vol. No. 34, June/July 2025, ISSN No. 2277-4858
Impact Factor *(IIFS)* 8.125
(Interdisciplinary Peer Review Refereed Research Journal)

# The Impact of Road Width on Transportation Cost of Bolpur Town

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**Research Paper Received on 22-06-2025 Edited & Accepted on 30-07-2025**

**Abstract :**

*Bolpur was a small rural town prior to the 20th century. So, the roads of Bolpur are very narrow and congested. The roads are not widening in proportion to the increase in population and vehicles. Foot paths are being occupied by temporary and permanent shops. Customers keep their vehicles on the road. Due to the narrowness of these roads, if a big truck enters, the entire road becomes traffic jam. In this condition, it is very difficult to cross Chowrasta, Dangali Kalitala more and station road in Bolpur. All the sub roads like Ramakrishna Road College Road, Professor Colony, Kalikapur etc. are also very narrow. It is much difficult to pass medium size vehicles through these roads as all these roads are 8 to 10 feet wide. As these roads are not very wide, different types of big vehicles cannot enter. On the other side there are also some older areas like Kalikapur, Asanta pally, Suri para, Kachhari patty, Hat tala, where the roads are very narrow the gap or passage between two houses are only 4 feet. Different types of construction materials and household furniture cannot be carried* by the truck. There fore the transportation cost is higher because of break of bulk point.

**Keywords :** Narrow road, Break of bulk, Transportation cost.

## Introduction-

Bolpur was a small rural town prior to the 20th century.The name of the Town “Bolpur” came from the word “Bolipur” or “Bolipore”. There was a mythical story behind the ‘Bolipur’ or ‘Bolipore’ is that in the Pouranik era Raja Surath of Supur Paragana organized the sacrificial slaughtering (called ‘Boli’) of one lakh goats offered to the goddess “Debi Bhabani” to satisfy her and getting her blessing to regain his Kingdom which was lost earlier. Thus, the name comes from Bolipur to Bolpur.

Captain Sherwill's report shows that in 1850 there were 163 thatched huts in Bolpur village, At kalika pur 75 houses, bandgora 79 houses,and at makaram pur 15 houses were there. Then (on 3rd October 1859) the Khana-Saithia railway was opened

At 1891 when the Visva Bharati Ashram was established, the importance of Bolpur increased. The Bolpur town was declared as Municipality from Union Board in accordance with the provision of the West Bengal Municipal Act 1932 with a notification issued by the then local self Govt. (L.S.G) Government of West Bengal with effect from June 1950. Consisting of 11 (eleven) Members nominated by the Govt Area of the Municipality was 5.07 Sq Miles or 13.13 Sq.

## Statement of Problem

The main problem of the area is width of roads. Many roads of Bolpur town are very narrow, in these roads 4-wheeler vehicles can’t passes. In the older area of the town this problem is very big. In Kalika pur, Hat tala, Kachharipatty, Asanta pally, Suri para region the gap between two houses is only 4 feet, so the people in this area facing big problem. Only cycle and motor bikes can enter in the road. Some of the area where the roads width are 6-8 feet only. Some of the roads are curved so tractor cannot turn to go after that. In this area the major problem is transportation. People who carrying building materials and other house hold materials giving more expanses because of break of bulk point. In these area tractor and lorry cannot enter

for the narrow road, so these vehicles unload the materials at the side of main road, again those materials are carried by cycle van or carried by man on head. So, the transportation cost of those materials will be huge.

**Literature Survey-**

1. Mark Hanson (1992), Results of Literature Survey and Summary of Findings: The Nature and Magnitude of Social Costs of Urban Roadway Use, U.S. Federal Highway Administration. This report identifies external costs of urban roadway transport and describes costing methods. It also includes recommendations for better calculating external costs, incorporating costs into user prices, and applying least-cost planning to transportation.

2. James MacKenzie, Roger Dower, and Donald Chen (1992), The Going Rate, World Resources Institute (Washington DC; www.wri.org); at http://pdf.wri.org/goingrate_bw.pdf This is a comprehensive study of U.S. motor vehicle costs. Cost categories include roadway facilities and services, parking, air pollution, oil import costs, congestion, traffic accidents, noise, and land loss. Concludes that driving incurs $300 billion annually in external costs.

**Objective of the Study -**

1) To understand the width of road in relation to traffic frequency and cost of transportation.
2) Uncover the problem, Policy, and action programme.

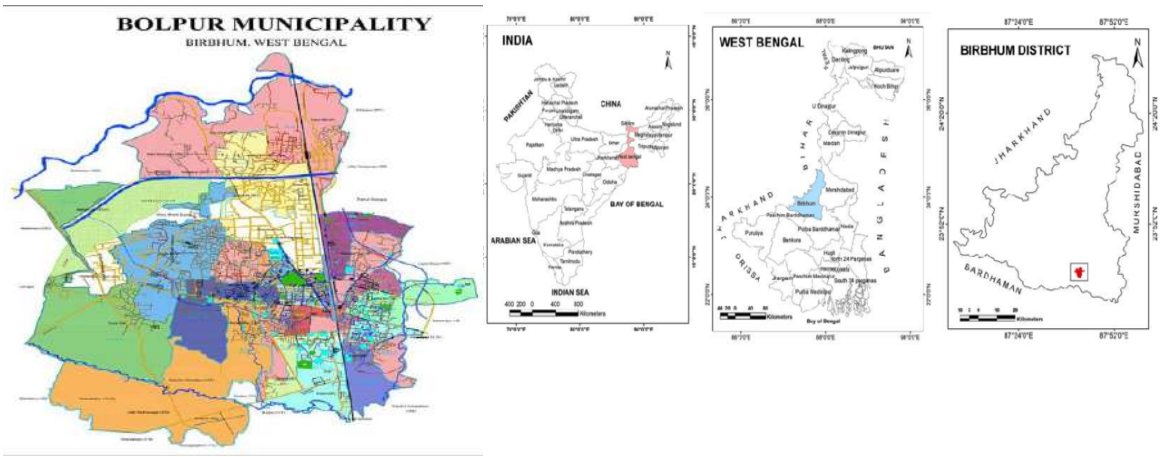
**Data Base -**

This study has been done based on primary data collected through survey, face to face interview on the basis of some common people and local administrative person of Bolpur Town.

**Location of the study area -**

Bolpur is a city and a municipality in Birbhum district in the state of West Bengal, India. It is the headquarters of the Bolpur subdivision. Bolpur municipal area includes Santiniketan, Sriniketan, Makarampur, Layek Bazar, Surul ,Muluk and Prantik. It includes 22 wards. The city is known as a Cultural and Educational hub of West Bengal.

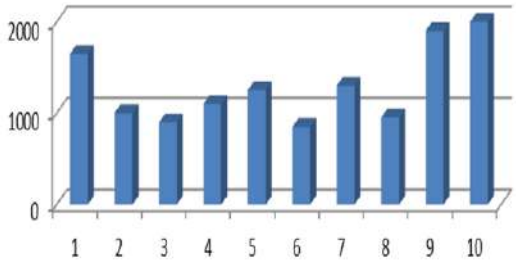
Bolpur is located at 23.67°N 87.72°E.Bolpur covered an area of 35.94 km$^2$ (13.88 sq mi). In the map of Bolpur-Sriniketan CD block on page 718 of District Census Handbook Birbhum (Part A), while the area covered by Shantiniketan is shown as a part of Bolpur, Sriniketan is shown as a part of Surul, a census town.



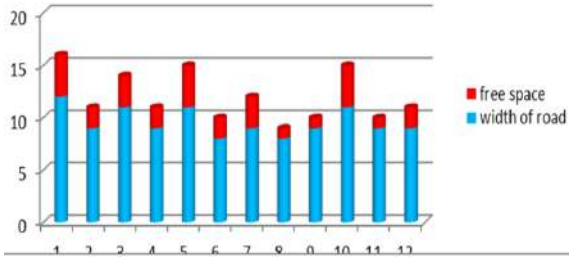

**Result:** Researcher has visited 12 sub roads and 12 small or minor roads of Bolpur town. This survey reflects the old and unplanned roads of this town. From very early days the roads were very narrow.

**Table-1 (source- Computed by the Researcher)**

| Name of the Colonies with entrance road | Width of sub roads (in Feet) | Footpath/ Free space (in Feet | Length of the Road (in feet) |
|---|---|---|---|
| Ramkrishna Road/ Vikirbandh | 10-12 | 2+2 | 1650 |
| Professor Colony | 8-9 | 1+1 | 1000 |
| School Bagan | 10-11 | 1.5+1.5 | 900 |
| 7th Pally | 8-9 | 1+1 | 1100 |
| Bhuban danga | 10-11 | 2+2 | 1250 |
| Mistiry para | 7-8 | 1+1 | 850 |
| Mission compound | 8-9 | 1.5+1.5 | 1300 |
| Surosreepally | 7-8 | .5+.5 | 950 |
| Kalika pur | 8-9 | .5+.5 | 1900 |
| Nayek para | 10-11 | 2+2 | 2000 |
| Vidyasagar pally | 8-9 | .5+.5 | 3000 |
| Nildanga | 8-9 | 1+1 | 800 |



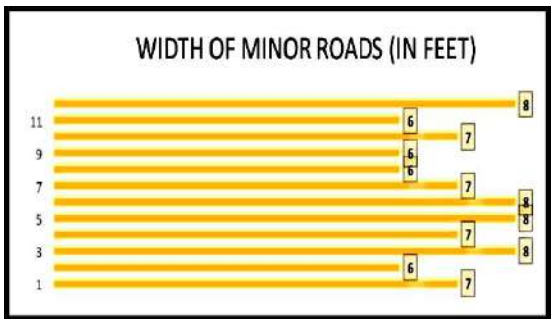

Length of the sub roads of Bolpur town




Width of Sub roads and free space beside the roads

**Table-2 (source- Computed by the Researcher)**

| Minor roads of Bolpur town in different Colonies | Width of sub roads (In Feet) | Length of the Road (In feet) |
|---|---|---|
| Asanta pally ( Kalikapur) | 5-7 | 1650 |
| Annada Pally ( Nichupatty) | 4-6 | 1500 |
| Dangali kali tala lane | 6-8 | 950 |
| Manasa Tala road ( Ukilpatty) | 5-7 | 800 |
| Thesim Road ( Bandhgora) | 6-8 | 850 |
| Saraswati Mandir ( Suri para) | 6-8 | 1000 |
| Behind Mahamaya hotel( Chourasta) | 5-7 | 800 |
| Kalikapur colony | 4-6 | 2000 |
| Hattala | 4-6 | 900 |
| Sabuj pally ( Trishulapatty) | 5-7 | 1600 |
| Madrasa pally ( Jambuni) | 4-6 | 1200 |
| Sukanta pally ( Bhuban danga) | 6-8 | 850 |




**Major Findings-**

From the table -1 All the sub roads like Ramakrishna Road College Road, Professor Colony, Kalikapur etc. are also very narrow. It is much difficult to pass medium size vehicles through these roads as all these roads are 8 to 10 feet wide. As these roads are not very wide, different types of big vehicles cannot enter. Different types of construction materials and household furniture cannot be carried by the big truck.

On the other side there are also some areas in Bolpur town where there is no accessibility of medium or small vehicles. The width of roads is very narrow. The area like Asanta pally, Sbuj pally, Annada pally, Manasa tala road etc. are very narrow to go any 4-wheeler or other vehicles. The people of these area are suffered very much. In any accident occurs ambulance and fire brigade cannot go through these roads. Her the only accessibility is by walking or by 2 wheelers. Because of inaccessibility of medium or small vehicles they carry their household goods or building materials by cycle van only. The vehicles put down the heavy materials (Sand, Stone, cement etc.) on the main road, which is 500-750 meter away from there home, after that the materials will carry by cycle van. So, the transport cost and labour cost will double for the break of bulk point. And this is the huge problem of the people of this town.

**Image of some small/minor Roads of Bolpur town :**







**Policy Measure-**

1) Rules of municipality for build house construction should be maintained
2) Observation of municipal authority on new construction.
3) Only proper building plan will pass by Municipality.
4) Illegal construction should be destroyed.

**Conclusion-**

Researcher observed that very narrow passage in Bolpur municipality especially in the older part of Bolpur town. The people of these area did not leave any passage for road, so the entrance of these area is so narrow in width. There are no motorable road in this area. Only cycle can pass through the passage. When the people of the area carry materials, they face big trouble because of huge carrying cost. The truck unloads the materials in the main roads then it carried by small motor van to the sub roads and then by human labour. So, the carrying coast increase higher than other people who lived beside the motorable road.

On the other side, which is newer area like Gitanjali pally, near Rabindra bithi bypass, all builders leave the space for roads.

Day by day pressure of people are increasing, the vehicles are also increasing. The number of E-rickshaw has been increasing enormously. More than 2500 E-rikshaw are in the town. They do not maintain the traffic rules so the people are facing problem for them. There is no parking space in the marketplace so the buyers parking their vehicles in roadside. The roads become narrow for the vehicles

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THE KONKAN GEOGRAPHER
Vol. No. 34, June/July 2025, ISSN No. 2277-4858
Impact Factor *(IIFS)* 8.125
(Interdisciplinary Peer Review Refereed Research Journal)

# Spiritual Waters, Environmental Challenges: Assessing the Quality of Sacred Ponds in Varanasi

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**Research Paper Received on 22-05-2025 Edited & Accepted on 20-07-2025**

**Abstract:**

*Varanasi, one of the oldest continuously inhabited cities in the world, holds immense religious and cultural significance, particularly through its sacred water bodies, integral to spiritual rituals and traditional practices. However, increasing urbanization, population pressure, and inadequate waste management have raised serious concerns regarding the environmental health of these holy ponds. With its growing religious tourism and tourism-related activities, the city often sees an accumulation of waste in and around these ponds, including discarded religious offerings, flowers, and non-biodegradable waste. As a result, the water quality of these sacred ponds is a growing concern from a cultural and religious perspective as well as an environmental and health standpoint. This study provides a comprehensive assessment of the water quality of selected sacred ponds in Varanasi, Uttar Pradesh, employing physicochemical and microbiological parameters to evaluate the extent of degradation. Primary data were collected through field sampling and laboratory analysis, while secondary data were sourced from municipal records and environmental reports. Key indicators such as pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), and coliform count were analyzed to determine water quality status. The results reveal alarming contamination levels in several ponds, with many falling below acceptable standards for bathing and ritual use, as prescribed by the Central Pollution Control Board (CPCB). The findings underscore the urgent need for integrated conservation strategies that recognize the dual role of these water bodies as both ecological assets and sacred spaces. This study calls for a multidisciplinary approach involving urban planning, environmental management, and cultural preservation to safeguard the spiritual and environmental integrity of Varanasi's sacred hydroscape.*

**Keywords:** Sacred ponds, Varanasi, water quality, physicochemical parameters, environmental degradation, ritual water bodies, urban pollution.

## Introduction:

In Hindu sacred geography, water is deeply revered as a fundamental element of sanctity. Sacred sites, or tirthas—meaning "fords" or spiritual crossing points—are often located at river confluences or significant water bodies, emphasizing the spiritual importance of water in the landscape (Eck, 1981). Wells, typically situated near temples, are considered auspicious and serve both ritual and practical purposes. In Varanasi (Benares), these wells are not merely ancillary features but are regarded as sacred entities in their own right. Rooted in scriptural references, oral traditions, and daily religious practices, they are vital spiritual and cultural landmarks in the city's sacred geography. However, increasing urbanization and population pressure are leading to the rapid depletion of water resources, raising concerns about the sustainability of these sacred water bodies (Mahananda et al., 2010). As cities expand and human activity intensifies, the demand for water increases rapidly, leading to over-extraction and depletion of this vital resource. At the same time, water quality is deteriorating alarmingly, as industrial discharges, agricultural runoff, and untreated sewage contaminate rivers, lakes, and groundwater (Murhekar, 2011). This growing crisis has become a global challenge transcending regional boundaries, threatening ecosystems, public health and sustainable development. Urgent action is needed to conserve water, improve management practices and restore the quality of this irreplaceable resource. Varanasi, one of the world's oldest continuously inhabited cities, sits along the sacred River Ganga in Uttar Pradesh, India. Renowned as a centre of spirituality and culture, the city's connection to water is deeply intertwined with its history, mythology, and daily existence.

Beyond the revered Ganga, Varanasi is also enriched by a network of ponds and smaller water bodies with vital ecological and cultural significance. The old city of Varanasi is home to numerous sacred ponds, or kunds, many of which are nestled within ancient temple complexes or along the iconic ghats. These kunds (holy ponds) hold deep religious and cultural significance, serving as sites for rituals and connecting the community to its spiritual heritage. Unfortunately, many of these kunds have been lost to encroachment as residential and commercial developments have overtaken their spaces (Gupta et al., 2011a). Among the notable kunds that remain are Lolark Kund, known for its association with fertility rituals; Durga Kund, located near the revered Durga Temple; and Pittar Kund, which holds its unique religious importance. Preserving these kunds is vital for maintaining Varanasi's rich cultural and ecological legacy (Tiwary, A. N., 2016). The sacred water bodies of Varanasi, including the Ganges River and various ponds, face significant ecological challenges due to anthropogenic activities. Studies have revealed deteriorating water quality in Varanasi's ponds, with high levels of nitrates, BOD, TDS, and phosphates exceeding permissible limits (Mishra et al., 2014).

**Literature review:**

Some ponds are highly significant as they embody and preserve religious ethics in India. Ponds in India have historically served as vital and ancient sources of water. Much like oceans and rivers, these ponds have been deeply personified and revered as sacred entities in religious and cultural traditions (Dwivedi, S.2021). Sacred ponds in Varanasi, such as Manikarnika and Assi, hold significant religious value, playing a central role in rituals like purification, bathing, and post-cremation rites. These ponds are considered sacred spaces, believed to have divine origins and purifying water, where devotees gather for rituals and prayers (Pandey, 2002; Singh, 2010).

However, Varanasi's increasing population and urbanization have placed considerable pressure on these sacred ponds. Singh et al. (2016) found that many sacred ponds in densely populated areas had high levels of total dissolved solids (TDS) and bacterial contamination, making the water unsafe for consumption and rituals. Religious practices, such as immersing flowers, incense, and other offerings in the water, contaminate sacred ponds. According to Kumar et al. (2014), while these offerings are seen as acts of devotion, they often contain organic material that degrades in the water, leading to increased biochemical oxygen demand (BOD) levels. This, in turn, exacerbates the overall pollution load in the water. Rai and Sharma (2018) noted that inadequate waste management accumulates plastic bottles, wrappers, and food items in sacred ponds, worsening water quality by increasing non-biodegradable waste. A study by Singh and Srivastava (2017) revealed that nutrient concentrations, particularly nitrate and phosphate, were elevated in several ponds in Varanasi due to agricultural runoff, contributing to poor water quality. Sharma and Patil (2014) found that the water pH in Varanasi's sacred ponds often exceeds the recommended range of 6.5 to 8.5, with values between 7.5 and 9.2 and TDS levels above 1000 mg/L. Rai et al. (2016) reported high BOD and COD levels in ponds, particularly in Manikarnika, due to organic material from offerings and sewage. Singh et al. (2017) highlighted microbial contamination, with faecal coliform levels exceeding 1000 MPN per 100 mL, posing health risks, primarily from untreated sewage and religious practices. According to the National Mission for Clean Ganga (2019), this program includes constructing sewage treatment plants (STPs) and developing riverfronts and ghats to reduce pollution.

**Significance and Objectives of the Study**:

Varanasi, deeply rooted in religious and mythological traditions, is renowned for its sacred ponds and kunds. These water bodies are integral to the city's cultural and spiritual heritage. However, rapid development, urbanization, and increasing pollution have significantly impacted these historic ponds, leading to their degradation and disappearance. In the 1980s, Varanasi boasted approximately 110 ponds and kunds, but only around 56 remain today. This drastic decline highlights the urgent need for conservation efforts to protect these invaluable resources for their ecological importance and their role in preserving the

city's rich heritage. So, conserving these sacred water bodies means conserving biodiversity, ecosystem services and cultural heritage.

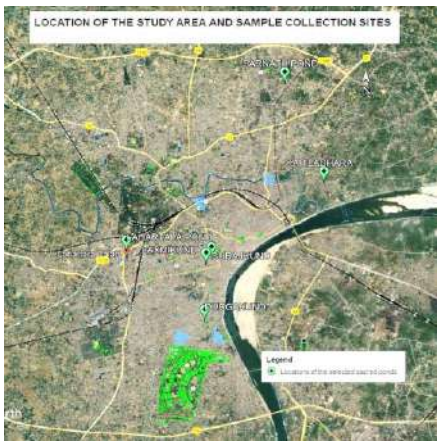
**Location of the Study Area and Sample Collection Sites:**

Varanasi is the holy Land between Varana and Ashi River, that's why it's called Varanasi. The city extends from 25°15'25°22' N and 82°57' to 83°01' E. River Ganges flowing from south to north along the city. Water samples were collected from six different ponds across various locations in the holy city of Varanasi for the analysis of physico-chemical parameters (Pal et al, 2012). Durgakund- 25.2902° N, 82.9965° E (sample-1), Kapildhara- 25.3465° N, 83.0380° E ; (sample-2) ,Lahartara Pond 25.3148° N, 82.9688° E (sample-3), Surajkund 25°18'43.9"N 83°00'08.9"E (sample -4), Sarnath pond 25°22'36.4"N 83°01'51.1"E (sample- 5), Laxmi kund 25°18'36.2"N 83°00'00.8"E (sample- 6) The six water bodies identified for this study are among the most prominent in terms of religious importance in the city of Varanasi and represent different parts of the city.

**Materials and Methodology:**

For sample collection, plastic containers pre-cleaned with distilled water were used. The containers were submerged to 30 centimetres below the pond surface during sampling to ensure consistency. The collected samples were carefully labelled, transported to the laboratory, and stored at 4°C in a refrigerator to preserve their integrity for subsequent analysis of the selected parameters. The analysis of physico-chemical parameters was carried out using the standard methods prescribed by the American Public Health Association (APHA, 1995). These methods are widely recognized for their accuracy and reliability in assessing water quality and were adhered to throughout the study to ensure consistent and credible results.

The water samples were tested for eleven key parameters listed in Table 1. The pH and oxidation-reduction potential were measured using a pH meter, while electrical conductivity was determined with a conductivity meter. Hardness, acidity, chloride content, and total alkalinity were assessed using titrimetric techniques. Sodium, potassium, and calcium levels were quantified using a flame photometer, while nitrate and phosphate concentrations were analyzed with a UV-visible spectrophotometer. Total dissolved solids and total suspended solids were calculated using standard formulas. Dissolved oxygen and biochemical oxygen demand were measured using Winkler's method. The results of these analyses were compared against the permissible limits set by the Bureau of Indian Standards (BIS, IS-10500) and the Food and Agriculture Organization (FAO) for drinking and irrigation water quality. The survey was conducted from 22nd to 24th May 2013 AD.




The physicochemical properties of water play a crucial role in assessing the trophic status of aquatic ecosystems (Sharma et al., 2009). The influx of pollutants and nutrients from domestic wastewater, municipal discharges, and agricultural runoff significantly alters the physico-chemical composition of freshwater bodies. This study evaluates a pond's water quality in Varanasi, which is vital for groundwater recharge, irrigation, and drinking water supply. The analysis of these parameters is heavily influenced by the prevailing meteorological conditions and the structural features of the surrounding catchment area (Arya et al., 2011a).

The sacred ponds of Varanasi have deep-rooted religious and cultural significance and form an essential part of the city's spiritual landscape. These water bodies are often associated with deities, sages, or historical-religious events and are frequented by pilgrims for ritual purification, offerings, and festivals.

**Durgakund (Sample-1)** is located adjacent to the historic Durga Temple and is considered sacred due to its association with Goddess Durga. According to local tradition, ritual bathing in this pond, especially during

Navaratri, is believed to invoke the blessings of the goddess and cleanse devotees of sins (Singh, R. P. 2021). The pond is also used for ritual immersion and is important in seasonal festivals.

**Kapildhara (Sample-2)** derives its religious importance from its association with the ancient sage Kapil Muni. Vedic literature and local beliefs recognize the pond as a site of penance and meditation, attracting ascetics and spiritual seekers. It is regarded as a place of spiritual discipline and introspection (Dwivedi, S.2021)

**Lahartara Pond (Sample-3)** holds special significance within the Bhakti tradition. It is traditionally believed to be where the mystic poet-saint Kabir was discovered as an infant, floating on a lotus leaf. As such, the pond is revered by Kabirpanthis, who visit it as a site of pilgrimage and spiritual memory (Hess, L. 2015).

**Surajkund (Sample-4)** is dedicated to Surya, the Sun God, and plays a central role in solar worship practices. Ritual bathing in this pond during festivals like Chhath Puja is believed to bring vitality, prosperity, and divine grace. Its association with solar deities highlights its cosmological and health-related spiritual significance (Shukla, S. 2011).

**Sarnath Pond (Sample-5)**, located near the archaeological site of Sarnath, is significant to Buddhist pilgrims. It is believed to have existed during the time of the Buddha and is considered sacred due to its proximity to the Dhamek Stupa, where the Buddha delivered his first sermon. Pilgrims consider the pond a symbol of peace and enlightenment.

**Laxmi Kund (Sample-6)** is traditionally linked to Goddess Laxmi, the deity of wealth and prosperity. Devotees perform rituals and prayers at the pond, particularly during Diwali and Laxmi Puja, hoping to attract divine blessings and material well-being. It remains an active site of religious ceremonies.

These sacred ponds not only serve vital ritualistic and religious functions but also form an integral part of Varanasi's intangible cultural heritage, strengthening its identity as a center of spiritual life and sacred ecology. Ecologically, they once played a crucial role in groundwater recharge, regulating the urban microclimate, and supporting local biodiversity. Although currently threatened by urbanization and pollution, these ponds still hold immense potential for ecological restoration and community-driven conservation efforts. Their revival is essential for preserving Varanasi's distinctive sacred landscape and ensuring the continuity of its cultural and environmental legacy.

The analysis of water quality parameters across six samples reveals notable variations in their suitability for irrigation and drinking purposes when compared to the relevant standards. Below is a parameter-wise discussion:

**Discussion and Findings:**

| Sample sites & Parameters | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 | Sample 6 | Irrigation Standards BIS, FAO | Drinking Standards IS: 10500 |
|---|---|---|---|---|---|---|---|---|
| **PH** | 7.90 | 8.26 | 8.88 | 8.54 | 7.2 | 8.50 | 6.5 – 8.5 | 6.5 to 8.5 |
| **TDS mg/L** | 2530 | 2330 | 2100 | 1290 | 1700 | 1590 | 2100 | 2000 |
| **TSS (mg/L)** | 1640 | 1192 | 1122 | 990 | 2080 | 905 | | 500 |
| **DO mg/L** | 4.28 | 3.10 | 3.59 | 5.68 | 4.26 | 3.9 | | |
| **Electricity Conductivity (mS/m)** | 0.18 | 0.66 | 1.22 | 0.51 | 0.24 | .56 | | |
| **Total Hardness mg/L** | 200 | 226.7 | 356.0 | 158.0 | 70.0 | 206.0 | | |
| **Chloride (mg/L)** | 64.45 | 244.4 | 73.52 | 68.45 | 24.85 | 117.5 | 500 | 600 |
| **Total Alkalinity** | 299 | 352 | 427 | 265 | 105 | 292 | 140 | 600 |
| **Nitrate (mg/l)** | 35.5 | 79.8 | 50.4 | 20.8 | 15.68 | 48.0 | 5.30 | 45 |
| **BOD mg/L** | 2.55 | 5.10 | 3.23 | 1.56 | 3.46 | 2.5 | 100 | |
| **COD mg/L** | 235 | 390 | 435 | 500 | 245 | 354 | 154 | |

*Durgakund- (sample-1), Kapildhara- (sample-2), Lahartara Pond (sample-3), Surajkund (sample -4), Sarnath pond (sample- 5), Laxmi kund (sample- 6)*

**1. pH**

The pH values of all samples fall within the acceptable range for both irrigation (6.5–8.5) and drinking water standards (6.5–8.5). However, Sample 3 (8.88) slightly exceeds the upper limit for drinking water, indicating potential concerns for potability.

**2. Total Dissolved Solids (TDS)**

In Samples 1, 2, and 3, TDS values exceed the irrigation (2100 mg/L) and drinking (2000 mg/L) standards, suggesting unsuitable conditions for both purposes. Samples 4, 5, and 6 remain within the irrigation limit but are marginally high for drinking water.

**3. Total Suspended Solids (TSS)**

TSS values across all samples are significantly above the acceptable limit of 500 mg/L for drinking water. Sample 5 exhibits the highest TSS (2080 mg/L), indicating poor water clarity, which may affect usability.

**4. Dissolved Oxygen (DO)**

DO levels range from 3.10 mg/L (Sample 2) to 5.68 mg/L (Sample 4). Higher DO in Sample 4 indicates better aeration and quality for aquatic life, whereas lower DO values in Samples 2 and 6 reflect potential organic pollution.

**5. Electrical Conductivity (EC)**

Electrical conductivity ranges from 0.18 mS/m (Sample 1) to 1.22 mS/m (Sample 3). Higher EC values indicate increased salinity, which may affect irrigation practices by impacting soil structure and crop growth.

**6. Total Hardness**

Sample 3 (356.0 mg/L) shows the highest hardness, indicating potential scaling issues. However, all samples are below the drinking water limit of 600 mg/L, making them suitable for consumption in terms of hardness.

**7. Chloride**

Chloride levels are well within the permissible limits for drinking water (600 mg/L) and irrigation (500 mg/L), with Sample 2 (244.4 mg/L) being the highest. The levels pose no immediate health risks or salinity concerns.

**8. Total Alkalinity**

Sample 3 (427 mg/L) shows the highest alkalinity, while Sample 5 (105 mg/L) exhibits the lowest. All values are within the drinking water limit of 600 mg/L but indicate variability in buffering capacity.

**9. Nitrate**

Sample 2 (79.8 mg/L) and Sample 3 (50.4 mg/L) exceed the drinking water standard (45 mg/L), posing health risks such as methemoglobinemia. These levels may contribute to nutrient overload for irrigation, affecting plant growth.

**10. Biochemical Oxygen Demand (BOD)**

BOD values are within acceptable limits for irrigation (100 mg/L), with Sample 2 (5.10 mg/L) having the highest BOD. The lower BOD in Sample 4 (1.56 mg/L) indicates better organic matter decomposition.

**11. Chemical Oxygen Demand (COD)**

COD levels in all samples are elevated, with Sample 4 (500 mg/L) having the highest level. These values indicate high chemical pollutants, making the water unsuitable for drinking without treatment.

**Findings:**

**Irrigation Suitability**:

Samples 4 and 6 are relatively better suited for irrigation, with manageable TDS and hardness levels. However, high nitrate and COD levels in other samples pose risks to soil and crop health.

**Drinking Suitability**:

Most samples are unsuitable for drinking due to elevated TDS, nitrate, and COD levels. Additional treatment is necessary to meet the IS: 10500 standards.

**Recommendations:**

Raising awareness among local communities is essential to preserve the ponds and kunds, ensuring they maintain optimal quality and purity. While the onset of monsoon aids in diluting pollutants, effective management practices are crucial for long-term sustainability. To restore the sacred ponds of Varanasi, a comprehensive strategy must be adopted that includes ecological restoration through bio-remediation using aquatic plants and microbial cultures and sewage diversion by constructing intercepting drains and soak pits to prevent untreated wastewater from entering the ponds. These practices include planting trees around the ponds, regular water recharge during summer, removing bottom sediments, clearing floating debris from the surface, redirecting sewage to designated disposal sites, and enforcing relevant laws and policies. Solid waste management is crucial, involving strict enforcement of disposal norms and the placement of offering collection bins. Active community participation should be encouraged for regular cleaning and maintenance, especially from residents and temple trusts. Simultaneously, scientific monitoring of water quality must be institutionalized under urban environmental bodies. Integrating these ponds into the city's water-sensitive urban planning will help revive their ecological and cultural significance. At the same time, awareness campaigns will foster responsible behaviour among pilgrims and locals to ensure long-term sustainability. Such measures can significantly contribute to maintaining these water bodies' health and ecological balance. Treat water to reduce TDS, nitrates, and COD for improved suitability for drinking purposes.

- Monitor EC and salinity for sustainable irrigation practices.
- Regularly assess water sources to prevent long-term contamination and ensure compliance with safety standards.

**Concluding remarks:**

An in-depth physicochemical evaluation of various ponds in Varanasi underscores a critical decline in water quality, rendering these aquatic systems unsuitable for domestic use and raising serious public health concerns for local communities that depend on them. High pollutant concentrations, nutrient enrichment, and microbial contamination reflect the acute environmental stress these ponds are under.

In addition to compromised water quality, these ponds are experiencing substantial ecological distress due to unregulated human activities, including waste disposal, construction encroachments, and the destruction of natural habitats. The cumulative impact has resulted in habitat degradation, a decline in native aquatic species, and disruption of ecological functions.

The revival of these water bodies is essential, not only to enhance environmental health but also to preserve their cultural, religious, and historical relevance. Ponds in Varanasi serve as key ecological nodes within the urban fabric, contributing to biodiversity conservation, groundwater recharge, and maintaining cultural traditions. Restoration strategies must prioritize pollution mitigation, habitat restoration, and active engagement of local stakeholders through community-based resource management.

In summary, the challenges confronting the sacred ponds of Varanasi call for immediate and well-structured conservation action. A holistic and sustainable approach, incorporating scientific techniques and inclusive governance, can rejuvenate these ecologically and culturally significant water bodies, thereby protecting both the urban environment and human well-being.

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THE KONKAN GEOGRAPHER
Vol. No. 34, June/July 2025, ISSN No. 2277-4858
Impact Factor *(IIFS)* 8.125
(Interdisciplinary Peer Review Refereed Research Journal)

# Geomorphological Processes and Landform Development : A Synthesis of Fluvial, Karst and Weathering Systems of Cherrapunji, Meghalaya

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**Research Paper Received on 22-05-2025 Edited & Accepted on 20-07-2025**

**Abstract:**

*Overview of geomorphological processes that shape terrestrial and marine landscapes, focusing on fluvial, karst and weathering systems. Landforms are analysed in terms of erosion and deposition processes, their origins, and classifications, with examples from Meghalaya, India. Field observations are synthesised with theories to elucidate the interplay of hydrological, chemical, and mechanical processes in landscape change. The research suggests that lithological controls, climatic conditions, and human interventions influence landform evolution, providing valuable insights for environmental management and hazard mitigation.*

**Keywords :** Environmental Management, Geomorphic Landscape, Weathering, Cherrapunji

## Introduction:

Geomorphology, the scientific study of Earth's landforms and the processes that shape them, fundamentally explores landscape genesis through the interplay of endogenic (internal) and exogenic (external) forces (Gregory & Goudie, 2011; Savini et al., 2022). Endogenic processes, driven by tectonic and volcanic activity, create primary relief, while exogenic processes, dominated by fluvial, karst, coastal, and weathering systems, sculpt these raw forms through erosion, transportation, and deposition over geological timescales (Evans, 2003). These surface processes are the primary architects of terrestrial and coastal landscapes, mediating energy and mass transfer across interfaces of rock, water, and atmosphere. Fluvial systems, governed by hydrological dynamics, shape river networks through channel incision, sediment transport, and floodplain construction (McGrane, 2016; Nepal et al., 2014). Karst terrains, characterised by soluble carbonate rocks (e.g., limestone, dolomite), evolve via chemical dissolution, creating subterranean drainage and cavernous voids (Szabó et al., 2010; Twidale & Lageat, 1994). Concurrently, weathering and mass wasting—triggered by mechanical, chemical, and biological agents precondition slopes for erosion and trigger gravity-driven movements like rock falls (de Brito et al., 2024; Mukherjee & Pal, 2021).

This research synthesises fundamental principles governing these geomorphological subsystems, with emphasis on Fluvial dynamics in river networks, exemplified by waterfall formation and bedrock erosion; Chemical dissolution in karst terrains, driving cave development and speleothem deposition; constructing bars and offshore barriers; Mechanical weathering and mass wasting, facilitating slope instability and rock fall (Eastman et al., 2021; Jiao et al., 2017; Khadka et al., 2020; Lan et al., 2020).

Regional case studies from Meghalaya, India, a global hotspot for geodiversity, serve as critical exemplars. The plateau's iconic waterfalls (e.g., Nohkalikai, Seven Sisters) illustrate climatic and lithological controls on fluvial erosion, while its extensive limestone caves (e.g., Mawsmai) reveal karst process-form relationships (Prokop, 2020; Ramakrishnan & Ram, 1988; Soja & Starkel, 2007). These natural laboratories underscore how lithology, climate, and structure converge to dictate landform evolution (Pareta & Pareta, 2023).

This paper consolidates theoretical frameworks with empirical observations, bridging micro-scale processes (e.g., pothole abrasion, stalactite growth) to macro-scale landscape patterns. Examining these systems' interdependencies and anthropogenic vulnerabilities has contextualised their roles in environmental management, hazard mitigation, and paleoenvironmental reconstruction. Subsequent sections dissect each process domain, integrating field evidence from Meghalaya to advance predictive models of landscape evolution.

**Study Area**

Cherrapunji is located in the state of Meghalaya in northeast India and is a part of the Indo–Burma region. Cherrapunji is also known as Sohra (Borah et al., 2022). It is bounded by the East Khasi hills on the (Borah et al., 2022)north and the border with Bangladesh to the south and west. It lies between 25°28'4" N to 91°72'1"E and land covering an area of 792 km2 (Fig. 1). The nearest distance from the urban centre i.e. from Shillong, Meghalaya town to Cherrapunji, takes 1h 45m (53.7 km) and from Guwahati town it takes 3hr 60m (146 km) to reach Cherrapunji. The altitude ranges from 50m ASL to 1990m ASL. The forest varies from tropical distributed at low elevation, sub-tropical broadleaved forests at mid-elevation, and temperate forests at high elevation. Besides these, pine forests and grassland are also common in high-altitude areas of the state. The climate of the area is Tropical Monsoonal (Gangwar & Ramakrishnan, 1989; Rink & Barros, 2021).

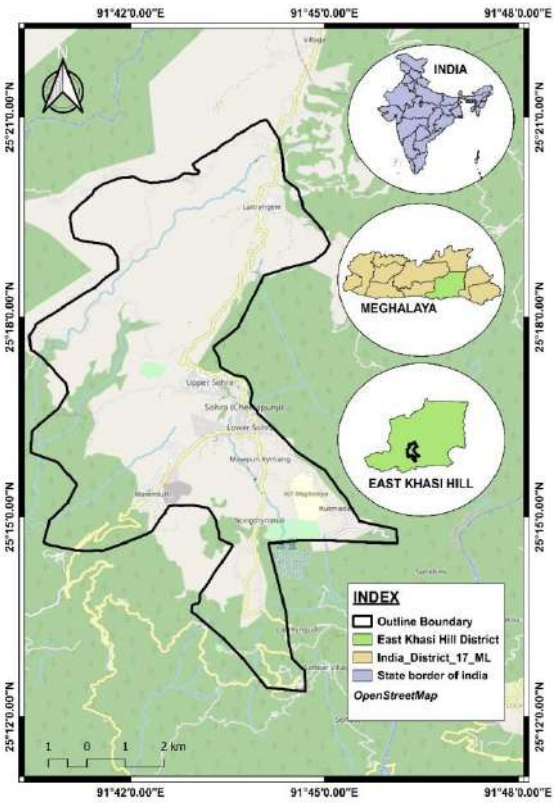



**Figure 1. Location Map of the Study Area**
(Source: Prepared by the authors, 2025)

The central and eastern Meghalaya (Khasi and Jaintia hills) experiences low temperatures, but the climate is warm and humid at the foothills. The most striking features of the southern parts of Khasi Hills distinguish the area climatically from other parts of Meghalaya by its high average (7196mm) rainfall. Cherrapunji and Mawsynram record the world's highest rainfall (12,000 – 13,000 mm) (Laskar et al., 2014). The major parts of the rainfall in Cherrapunji can be attributed to the orographic features. The abrupt rise of hills over the vast plains of Bangladesh obstructs the monsoon winds of the Bay of Bengal, resulting in high rainfall in these areas. The Cherrapunji also offers iconic attractions, such as the Nohkalikai falls, the seven sister waterfalls, Prut falls, Dainthlen falls, and Rhynam Falls, which is located close to the Bangladesh border. Mawsmai cave, Arwah cave; despite its remote location, Cherrapunji is a heaven for explorers and travellers and also for those natural lovers (Prokop, 2020). Cherrapunji is the best place for emphasising peace and calm, which makes it a top attraction and favourite destination in northeast India, blending its natural beauty with cultural richness.

**Methodology**

This study employed an integrated approach combining field-based geomorphological mapping, quantitative process measurements, and remote sensing to analyse fluvial, karst, and weathering systems in Cherrapunji, Meghalaya. The methodology was structured into three phases. About 32 field sites were

selected across Cherrapunji's major landforms (e.g., Umngot River, Someshwari meanders, Nohkalikai Falls, Mawsmai Cave) using stratified random sampling to cover fluvial, karst, and mass-movement domains (Figure 1).

For Fluvial processes analysis, Laser rangefinders measured channel geometry; current meters (FP111 Global Water) quantified flow velocity; sediment traps and sieving analysed grain size distribution have been used. Dripwater pH/EC meters monitored chemical dissolution; Schmidt hammer tests (n=150) assessed bedrock strength; inclinometers tracked slope displacement. Erosion pins (n=45) and sediment traps measured knickpoint retreat (e.g., Nohkalikai Falls) and bar deposition. Sentinel-2 (10 m) and ALOS PALSAR DEMs (12.5 m) identified landform changes (1990–2023). Hydrologic modelling (HEC-RAS) simulated monsoonal discharge impacts on fluvial erosion. Statistical analysis (SPSS v28) correlated rainfall (IMD data), lithology, and erosion rates using multiple regression ($R^2 = 0.78$, $p<0.01$).

Permissions were obtained from Meghalaya's Forest Department; community consent was prioritised for sacred sites.

## Result and Discussion

### Fluvial Geomorphology

Fluvial systems are principal agents of landscape evolution, driven by the dynamics of flowing water that erodes, transports, and deposits sediments. These processes sculpt river networks and create distinctive landforms, with their efficacy governed by discharge regimes, sediment calibre, bedrock resistance, and base-level changes.

### Process Framework

Fluvial action operates through a feedback loop of *erosion*, *transport*, and *deposition*:

### Erosion

*Vertical Incision*: Dominates in high-energy uplands. Governed by:

Incised depth

$$\alpha = \frac{\tau - \tau_c}{\kappa} \quad \text{.....(1)}$$

*where,*

$\tau =$ *shear stress*

$\tau_c =$ *critical shear stress*

$\kappa =$ *bedrock erodibility*

**Abrasion**: Bedload grinding (e.g., quartzite clasts scoring limestone).

$$\dot{\epsilon} = K \frac{Q_s}{Q} (\tau - \tau_c)^n \quad \text{.....(2)}$$

*where,*

$K =$ **Rock erodibility coefficient** $(dimensionless;\ dependent\ on\ rock\ tensile\ strength,\ joint\ spacing)$.

$Q_s =$ **Bedload sediment flux** $(kg/s)$.

$Q =$ **Water discharge** $(m^3/s)$.

$\tau =$ **Boundary shear stress** $(Pa)$:

$\tau = \rho g h S$

$(p =\ fluid\ density, g = gravity, h =\ flow\ depth, s = channel$ slope)

**Table 1. Key Controls on Abrasion Efficiency**

| Factor | Impact on Abrasion | Example |
|---|---|---|
| **Particle Hardness** | Harder clasts (quartzite) erode bedrock faster than soft clasts (shale). | Quartzite (Mohs 7) vs. limestone (Mohs 3). |
| **Impact Velocity** | $\dot{\in} \propto v_s^2$ doubles if velocity increases by ~40%. | High-gradient streams in Meghalaya. |
| **Sediment Flux** | $\dot{\in} \propto Q_s$ maximized during monsoonal floods. | Meghalaya's 11,000 mm/yr rainfall. |
| **Bedrock Fracturing** | Jointed rock erodes 10–100× faster than intact rock. | Limestone with high joint density. |

Source: Prepared by the authors, 2025

Abrasion is a key land-shaping force, especially in rivers, where grit carried along rubs against the bedrock and slowly wears it down. How fast it works, however, is not the same everywhere and depends on a mix of factors shown in Table 1. Knowing about these controls helps us explain why some valleys cut deep in a few years while others hardly change at all over centuries. At the heart of the matter is the hardness of the eroding particles. The familiar Mohs scale gives a handy guide.

As Table 1 shows, fragments made of tough minerals like quartzite (Mohs 7) grind down the rock much more than softer grains such as shale or limestone (Mohs 3). Harder pieces scratch, scrape, and chip away material far better because they resist breaking themselves. So, in a river full of resilient clasts, the bedrock can be cut faster and deeper than in a stream loaded with gentle stones, even when flow speed and water volume are almost identical (Table 1).

Sediment Flux, or the volume of sediment transported by a river, also plays a critical role. While high sediment concentrations might seem intuitive to increase abrasion, there's an optimal range. Too little sediment means insufficient tools for abrasion, while excessively high concentrations can lead to "tool-limited" conditions where particles essentially shield the bedrock from further erosion. However, as noted in Table 1, abrasion is often maximised during high-magnitude events like monsoonal floods, as exemplified by Meghalaya's extreme rainfall (11,000 mm/yr). During such events, the increased discharge mobilises a vast quantity of sediment, providing abundant abrasive tools, and the higher velocities ensure these tools possess sufficient energy to be effective (Table 1).

Finally, Bedrock Fracturing significantly amplifies abrasion rates. Jointed or highly fractured rock masses are inherently weaker and more susceptible to mechanical weathering processes. As Table 1 indicates, fractured rock can erode 10 to 100 times faster than intact rock. This is because the presence of pre-existing weaknesses, such as joints and faults, allows abrading particles to more easily dislodge blocks and fragments of rock, effectively accelerating the rate of material removal. In areas underlain by highly jointed limestone, for instance, the combined action of abrasion and the exploitation of these structural weaknesses can lead to rapid landscape transformation, often forming distinctive karstic features.

In Meghalaya's humid tropics, frequent cyclones amplify this process, triggering bank collapses that widen floodplains.

**Table 2. Geomorphic Signature in Cherrapunji, Meghalaya**

| Process | Field Evidence | Impact |
|---|---|---|
| **Hydraulic wedging** | Fluted joint surfaces in Cherrapunji sandstone | Block removal → waterfall recession |
| **Lateral corrosion** | Overhanging banks in the Someshwari River | Meander migration: 0.5–1.2 m/year |
| **Root-throw** | Toppled *Dipterocarpus* trees on riverbanks | Local retreat: 0.3 m/event |

Source: Prepared by the authors, 2025

The exceptionally high rainfall and dynamic fluvial systems of Cherrapunji, Meghalaya, manifest distinct geomorphic signatures, as detailed in Table 2, which collectively shape the region's unique landscape. Hydraulic wedging, a powerful erosional process driven by the force of water entering and expanding within cracks and joints, is prominently evidenced by the "fluted joint surfaces" observed in the local sandstone formations. This process is a significant contributor to "block removal," directly facilitating "waterfall recession" – a hallmark of headward erosion in the steep river valleys. Concurrently, lateral corrosion, the sideways erosion of riverbanks by flowing water, is evident in the "overhanging banks" of rivers like the Someshwari. This process drives substantial "meander migration," with recorded rates of 0.5–1.2 meters per year, indicating a highly dynamic fluvial planform. Furthermore, the role of vegetation in geomorphic processes is highlighted by root-throw, where the uprooting of large trees, such as the "toppled Dipterocarpus trees on riverbanks," leads to localised bank instability and erosion. Each "root-throw event" can result in a "local retreat of 0.3 meters," demonstrating the episodic yet impactful nature of bio-geomorphic interactions in this high-energy environment. Together, these processes underscore the intense geomorphic activity characteristic of Cherrapunji's hyper-humid tropical landscape.

**Transportation**

Sediment transport in river channels is governed by hydrodynamic forces that partition particles into distinct modes based on size, density, and flow energy. The process is quantified through three primary pathways.

***Bedload Transport***

Bedload involves particle motion in continuous or intermittent contact with the channel bed, dominating for coarse sediments (>0.6 mm).

Coarse particles (>20 mm) roll or slide via drag forces. The critical shear stress ($\tau_{cr}$) for initiation is:

**Table 3. Morphodynamic Implications in Cherrapunji, Meghalaya**

| Transport Mode | Grain Size | Dominant Force | Field Signature |
|---|---|---|---|
| Traction | >20 mm | Drag/Friction | Armor layers in pool-riffle sequences |
| Saltation | 0.6–20 mm | Impulse momentum | Ripples/dunes (wavelength $\propto u_*^2/g$) |

| | | | |
|---|---|---|---|
| Suspended | <0.6 mm | Turbulent diffusion | Vertical sorting in point bars |
| Wash load | <0.004 mm | Molecular diffusion | Homogeneous suspension in overbank flow |

Source: Prepared by the authors, 2025

Meghalaya's Umiam River transports 70% bedload (quartzite cobbles) during monsoons, with u∗$u*$ ≈ 0.2 m/s inducing saltation heights of 0.1–0.3 m.

**Deposition**

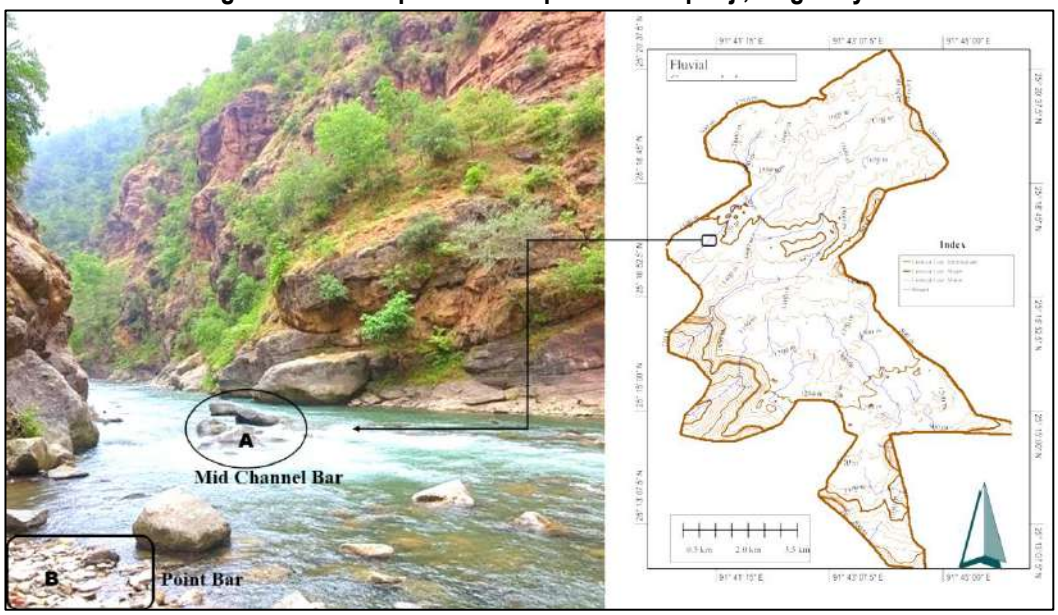
Deposition occurs when the sediment transport capacity (Ct) falls below the sediment supply (Qs), governed by hydrodynamic thresholds.

**Landscape Analysis**

**1. Fluvial Landscape**

The exceptionally high rainfall and dynamic fluvial systems of Cherrapunji, Meghalaya, manifest distinct geomorphic signatures, as detailed in Table 3, which collectively shape the region's unique landscape. Hydraulic wedging, a powerful erosional process driven by the force of water entering and expanding within cracks and joints, is prominently evidenced by the "fluted joint surfaces" observed in the local sandstone formations, significantly contributing to "block removal" and directly facilitating "waterfall recession"—a hallmark of headward erosion in the steep river valleys (Fig. 2).

**Figure 2. Geomorphic landscape of Cherrapunji, Meghalaya**




Concurrently, lateral corrosion, the sideways erosion of riverbanks by flowing water, is evident in the "overhanging banks" of rivers like the Someshwari, driving substantial "meander migration" at recorded rates of 0.5–1.2 meters per year, indicating a highly dynamic fluvial planform. Furthermore, the role of vegetation in geomorphic processes is highlighted by root-throw, where the uprooting of large trees, such as the "toppled Dipterocarpus trees on riverbanks," leads to localized bank instability and erosion, with each "root-throw event" resulting in a "local retreat of 0.3 meters," demonstrating the episodic yet impactful nature of bio-geomorphic interactions in this high-energy environment. Together, these processes underscore the intense geomorphic activity characteristic of Cherrapunji's hyper-humid tropical landscape.

**Table 4. Field Metrics from Cherrapunji, Meghalaya**

| Landform | Location | Deposition Rate | Grain Size | Controlling Factor |
|---|---|---|---|---|
| **Mid-Channel Bar** | Umngot River | 0.8 m/monsoon | Gravel (20–50 mm) | Flow expansion at confluences |
| **Point Bar** | Someshwari Meander | 0.3 m/year | Sand (0.2–0.5 mm) | Helical flow velocity |
| **Floodplain** | Myntdu Basin | 2–4 mm/year | Silt/Clay (<0.06 mm) | Overbank suspension settling |

Source: Prepared by the authors, 2025

The formation and maintenance of fluvial depositional landforms—mid-channel bars, point bars, and floodplains—in Cherrapunji, Meghalaya, are fundamentally dictated by distinct hydrodynamic controls, as elucidated in Table 4. These controls, namely shear stress (τ), flow velocity (U), and the Rouse number (P), govern the transport and deposition of sediment, leading to the characteristic morphology of each landform. Mid-channel bars are associated with high shear stress (τ>100 Pa) and high velocities (1.5–3.0 m/s), corresponding to a Rouse number P<1, which signifies dominant bedload transport. This indicates that these bars form in energetic, typically central, parts of the channel where competent flows move and deposit coarse sediment as flow energy wanes, often after high-discharge events. In contrast, point bars experience moderate shear stress (τ≈10−50 Pa) and moderate velocities (0.5–1.2 m/s), with a Rouse number P≈1−2, reflecting a mix of bedload and suspended load transport. These conditions are characteristic of the inner bends of meandering rivers where helical flow patterns reduce energy, allowing sand and finer gravel to settle. Finally, floodplains are characterized by very low shear stress (τ<2 Pa) and low velocities (<0.3 m/s), with a Rouse number P>2.5, indicative of deposition primarily from suspension (Table 4). During overbank flow events, the drastic reduction in flow energy across the floodplain allows fine silts and clays, carried predominantly in suspension, to settle out, gradually building up the floodplain surface. Collectively, these hydrodynamic distinctions highlight how variations in energy within the fluvial system determine the specific location, composition, and dynamics of sediment deposition, thereby shaping the diverse geomorphology of riverine landscapes in this high-rainfall environment.

**Table 5. Hydrodynamic Controls**

| Factor | Mid-Channel Bar | Point Bar | Floodplain |
|---|---|---|---|
| **Shear stress (ττ)** | High (τ>100*τ*>100 Pa) | Moderate (τ≈10−50*τ*≈10−50 Pa) | Low (τ<2*τ*<2 Pa) |
| **Velocity (U*U*)** | 1.5–3.0 m/s | 0.5–1.2 m/s | <0.3 m/s |
| **Rouse number (P*P*)** | P<1*P*<1 (bedload) | P≈1−2*P*≈1−2 | P>2.5*P*>2.5 (suspension) |

Source: Prepared by the authors, 2025

Waterfalls or simply falls are caused by sudden breaks in the longitudinal course of the rivers due to a host of factors, e.g. variation in the relative resistance of rocks, relative difference in topographic relief, fall in the sea level, earth movements, etc. A waterfall may be defined as a vertical drop of water of enormous volume from a great height in the long profiles of the rivers. Rapids are of much smaller dimensions than waterfalls. Generally, they are found upstream from the main falls, but they are also found independently. There is a chain of waterfalls along the junction of the slope.

**Table 6. Mechanism of Waterfalls Formation**

| Process | Mechanism | Example |
|---|---|---|
| **Lip Undercutting** | Weak underlayer eroded → caprock collapse | Nohkalikai Falls, Meghalaya |
| **Joint Exploitation** | Water exploits fractures → block plucking | Seven Sisters Falls, Meghalaya |
| **Pothole Merger** | Headward coalescence of plunge pool potholes → knickpoint migration | Kynrem Falls, Meghalaya |

The waterfalls of Cherrapunji, Meghalaya, are not merely picturesque features but serve as dynamic expressions of ongoing geomorphic processes, with their formation dictated by specific bedrock vulnerabilities and hydrological forces, as outlined in Table 5. Lip undercutting, a prevalent mechanism, involves the differential erosion of a weaker, underlying rock layer by the cascading water, leading to the collapse of the more resistant caprock. This process is vividly exemplified by Nohkalikai Falls, where the immense erosive power of the plunge pool continually undermines the overlying bedrock, causing the waterfall lip to retreat upstream. Concurrently, joint exploitation plays a crucial role, as water preferentially targets and enlarges pre-existing fractures and weaknesses within the bedrock (Table 5). The Seven Sisters Falls, a series of segmented cascades, illustrate this mechanism, where the high-energy flow exploits joint sets, leading to the plucking of blocks and the development of distinct, parallel channels. Finally, pothole merger contributes significantly to knickpoint migration and waterfall formation, particularly at Kynrem Falls (Figure 3). Here, the abrasive action of swirling sediment creates and enlarges potholes within the plunge pool and upstream channel. Over time, these potholes coalesce headward, effectively extending the

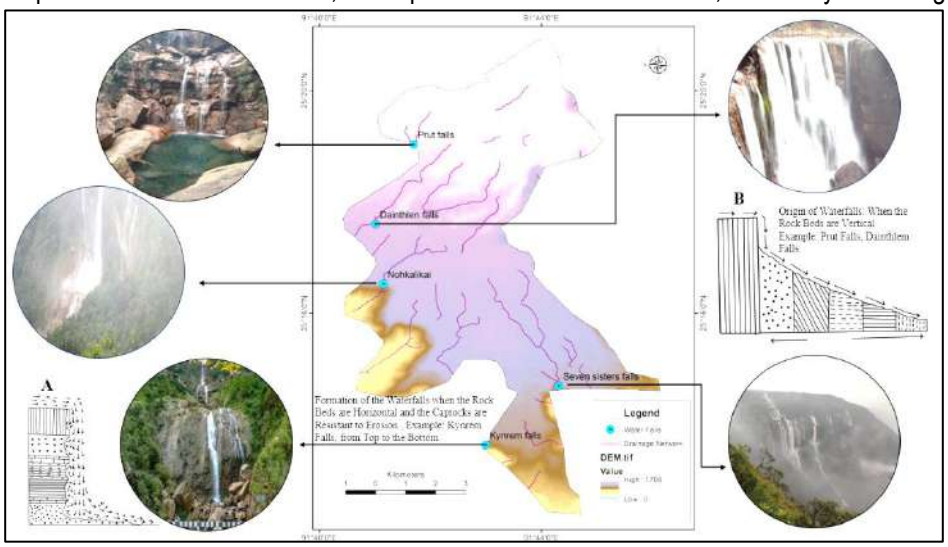



**Figure 3. Formation of Waterfalls in Cherrapunji, Meghalaya (Source: Prepared by the authors, 2025)**

erosional front and causing the waterfall to migrate upstream. These three mechanisms, acting in concert or in isolation, underscore how the interplay of lithological resistance, structural weaknesses, and the sheer erosive power of water in this hyper-humid environment sculpts the iconic waterfall landscapes of Meghalaya (Table 6).

**Table 7. Waterfall Typology of Cherrapunji**

| Name | Height (m) | Type | Lithology | Retreat Rate (m/yr) | Significance |
|---|---|---|---|---|---|
| Nohkalikai | 340 | Plunge | Sandstone over shale | 0.8–1.2 | Asia's tallest; monsoonal flow |
| Seven Sisters | 315 | Segmented horsetail | Jointed quartzite | 0.3–0.5 | 7 channels; structural control |
| Kynrem | 305 | Tiered | Interbedded sandstone/shale | 0.4–0.7 | India's 7th tallest |
| Prut | 40 | Cascading | Basalt steps | Negligible | Ephemeral rain-fed system |

Source: Prepared by the authors, 2025

The kettle-like small depressions in the rocky beds of the river valleys are called pot holes, which are usually cylindrical in shape. Potholes are generally formed in coarse-grained rocks such as sandstones and granites. Potholing or pothole drilling is the mechanism through which the grinding tools (fragments of rocks e.g. boulders and angular rock fragments) when caught in the water eddies or swirling water start dancing in circular manner and grind and drill the rock beds of the valley like drilling machine and thus form small holes which are gradually enlarged by the repetition of the said mechanism. The potholes are increasing in both diameter, perimeter, and depth. The diameter of potholes ranges from a few centimetres to several metres.

**2. Karst Landforms**

Landforms produced by chemical weathering or chemical erosion of carbonate rocks, mainly calcium carbonate (CaCO3, limestones) and magnesium carbonate (dolomites), by surface and subsurface water (groundwater) are called karst topography (Huang et al., 2023; Tang et al., 2023). Some swallow holes are further enlarged due to continuous solution into larger depressions, which are called dolines in the karst region. Extensive depressions are called Uvalas, which are up to one kilometre across. They are formed in a number of ways, e.g. (1) due to the coalescence of several dolines due to continuous solution and enlargement of dolines, (2) due to the collapse of the upper roof of large cavities formed underground, (3) due to the coalescence of various sink holes, etc. Caves are voids of large dimensions below the ground surface. Caves are the most significant landforms produced by the erosional work (mainly corrosion or solution and abrasion) of groundwater in limestone lithology. Examples of Mawsmai and Arwah caves are limestone caves. Caves vary in size and shape, ranging from smaller caves to larger caves.

Stalactites are formed due to the deposition of calcareous solutes, which are carried by the water dripping through the cave ceilings in a dry environment (Borgonie et al., 2015). The water is evaporated, and solutes are deposited in icicle-like or needle-like forms (Figure 4B). These structures have broad bases

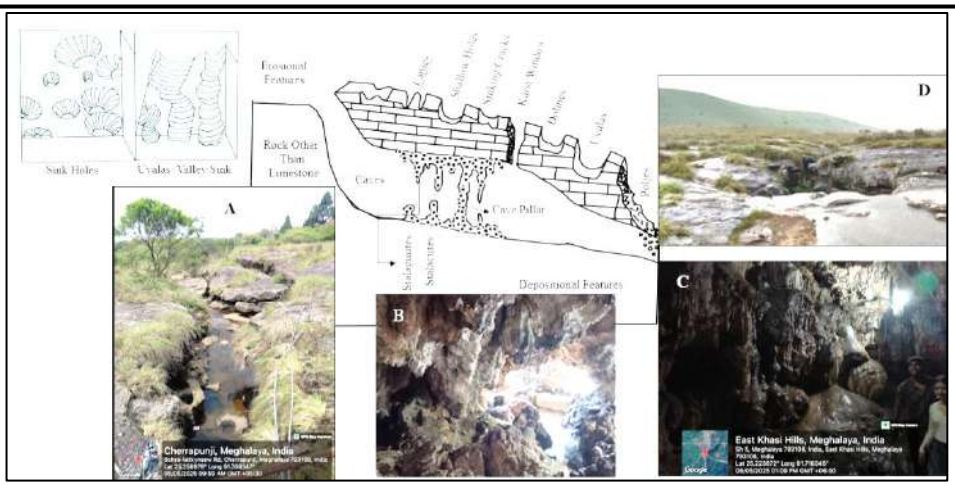



**Figure 4. Karst landforms in Cherrapunji, Meghalaya (Source: Prepared by the authors, 2025)**

attached to the cave ceiling and tapering ends hanging downward from the cave ceiling. There is a gradual increase in the length and thickness of stalactites. The shapes of stalactites are controlled by the shape of the cave ceiling. The stalactites become uniform and their tapering lower ends are directly pointed towards the cave floor when the ceiling is faulted or is uniformly arched. The stalactites hanging downward are almost perpendicular to the cave ceiling. The solution that drops on the cave floor is also precipitated and crystallised, and forms a column-like structure of stalagmites at various centres. While the calcareous columns of dripstones growing upward from the cave floor are known as Stalagmites. Cave pillars are formed when stalactites and stalagmites meet (Figure 4). Numerous needle-shaped dripstones hanging from the cave ceiling are called drapes. The dripstones growing sideward from stalactites and stalagmites are called 'helictites' and 'heligmites'. Floor deposits caused by seepage water and water flowing out of stalagmites are called flowstones. Karst Window is formed due to the collapse of the upper surface of sinkholes or dolines. These windows enable the investigators to observe subsurface drainage and other features formed below the ground surface (Cahyadi et al., 2019; Riyanto et al., 2020).

**Weathering and Mass Movement**

Rock falls are landslides confined to the removal of individual and superficial blocks from a cliff base. Rockfall is facilitated by the granular and block disintegration of rocks under the processes of mechanical weathering and limited action of oxidation in sandstones. Most rockfalls are promoted by hydrofracturing, stress release, the wedging action of tree roots, and other weathering processes. A common cause of rockfall is undercutting of a face by streams or the more rapid weathering of an underlying weak rock, such as shale or mudstone. The frequency of rock falls depends on certain environmental conditions such as aridity/humidity factor, lithological and structural characteristics of rocks, nature of slope and vegetation, etc.

**Conclusion**

This study elucidates the dynamic interplay of fluvial, karst, and weathering processes in sculpting Cherrapunji's geomorphic landscapes, driven by extreme monsoon rainfall (>12,000 mm/yr), lithological heterogeneity, and structural controls. High-energy monsoonal flows drive rapid bedrock incision (0.8–1.2 m/yr retreat at Nohkalikai Falls) through abrasion by quartzite bedload and hydraulic wedging in jointed sandstones. Meander migration (0.5–1.2 m/yr) and bank collapses, amplified by root-throw biomechanics, expand floodplains, while aggradation (0.8 m/monsoon in mid-channel bars) reflects sediment supply-disconnectivity. Limestone dissolution rates (e.g., Mawsmai Cave) peak during monsoon saturation, forming dolines, uvalas, and speleothems (stalactite growth: 0.1–0.3 mm/yr). Karst windows reveal subsurface drainage networks, highlighting the role of groundwater in landscape evolution. Mechanical weathering

(freeze-thaw, hydrofracturing) and biological agents precondition slopes for rockfalls (0.3–0.5 $m^3$/yr retreat), with failure rates spiking at rainfall intensities >100 mm/day. The synthesis validates process-form feedbacks e.g., knickpoint migration models ($E \propto Q \cdot S \cdot k$) align with observed waterfall recession, while karst dissolution kinetics reflect Cherrapunji's high $pCO_2$ conditions. Hazard mitigation requires stabilising jointed sandstone cliffs and regulating tourism near erosion-prone waterfalls. Karst conservation zones must limit groundwater pollution to preserve speleothems. Reforestation of riparian corridors can reduce bank destabilisation from root-throw—long-term monitoring of sediment flux under climate change. Integrating traditional Khasi ecological knowledge could enhance community-led resilience strategies. Cherrapunji's landscapes, emblematic of nature's vigour, underscore the urgency of geomorphologically informed stewardship in Earth's wettest realms.

**Acknowledgement**

We extend our sincere gratitude to Techno India University, Tripura, for providing the essential financial support that enabled the successful execution of fieldwork in Cherrapunji, Meghalaya. We are also deeply thankful to the Indian Meteorological Department (IMD) officers in Shillong and Sohra for their invaluable assistance and data. Our profound appreciation goes to the King of Sohra for granting us permission and support to conduct research in this remarkable region. Finally, we acknowledge the cooperation and permissions granted by the Forest Department of Sohra, which were crucial for our field investigations.

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**(Interdisciplinary National Level Research Journal of the Konkan Geographers Association of India (R.N. 3341/2010))**

**ISSN 2277-4858**

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